PB80-175508

Workbook/Users Manual for Prediction of Instantaneously Dumped Dredged Material

JBF Scientific Corp.
Wilmington, MA

Prepared for

Corvallis Environmental Research Lab., OR

Feb 80

U.S. Department of Commerce
National Technical Information Service
NTIS

United States
Environmental Protection
Agency

Environmental Research
Laboratory
Corvallis OR 97330

EPA-600/3-80-034
February 1980

PB80-175508

Research and Development

EPA

Workbook/Users Manual for Prediction of Instantaneously Dumped Dredged Material

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

RESEARCH REPORTING SERIES

Research reports of the Office of Research and Development, U.S. Environmental Protection Agency, have been grouped into nine series. These nine broad categories were established to facilitate further development and application of environmental technology. Elimination of traditional grouping was consciously planned to foster technology transfer and a maximum interface in related fields. The nine series are:

1. Environmental Health Effects Research
2. Environmental Protection Technology
3. Ecological Research
4. Environmental Monitoring
5. Socioeconomic Environmental Studies
6. Scientific and Technical Assessment Reports (STAR)
7. Interagency Energy-Environment Research and Development
8. "Special" Reports
9. Miscellaneous Reports

This report has been assigned to the ECOLOGICAL RESEARCH series. This series describes research on the effects of pollution on humans, plant and animal species, and materials. Problems are assessed for their long- and short-term influences. Investigations include formation, transport, and pathway studies to determine the fate of pollutants and their effects. This work provides the technical basis for setting standards to minimize undesirable changes in living organisms in the aquatic, terrestrial, and atmospheric environments.

This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-600/3-80-034	2.	3. RECIPIENT'S ACCESSION NO. PB80 175508
4. TITLE AND SUBTITLE Workbook/Users Manual for Prediction of Instantaneously Dumped Dredged Material		5. REPORT DATE February 1980 issuing date
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) L. R. Davis, G. W. Bowers, and M. K. Goldenblatt		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Environmental Protection Agency, CERL Corvallis, Oregon 97330 and JBF Scientific Corporation Wilmington, Massachusetts 01887		10. PROGRAM ELEMENT NO. 1BA608
		11. CONTRACT/GRANT NO. R-804994
12. SPONSORING AGENCY NAME AND ADDRESS Corvallis Environmental Research Laboratory Office of Research and Development U.S. Environmental Protection Agency Corvallis, Oregon 97330		13. TYPE OF REPORT AND PERIOD COVERED Final - Aug.1976 - July 1979
		14. SPONSORING AGENCY CODE EPA/600/02
15. SUPPLEMENTARY NOTES		

16. ABSTRACT

This manual describes the operation and use of a computer model developed to predict the physical fate of dredged material instantaneously released into the water column. The model predicts the spacial distribution of various components of the dumped material as a function of time. Output includes material concentration and position while in the water column and material mound height and concentration after bottom impact. Included in this report are a description of the model's structure and a complete explanation of its input/output formats. In addition, the model has been run for a matrix of input conditions. Both the input and output of these runs are presented as tables in dimensionless form. These working tables can be used to approximate the fate of dredged material without requiring the user to actually run the model. Several examples showing how these tables can be used are also given. The first phase of this work was done by JBF Scientific under sponsorship of the U.S. Environmental Protection Agency. The workbook portion was done in-house at the EPA Corvallis Environmental Research Laboratory.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Dredged material disposal Waste disposal Mathematical models	Dredge Spoil	13-B

18. DISTRIBUTION STATEMENT Unlimited	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

EPA-600/3-80-034
February 1980

WORKBOOK/USERS MANUAL FOR PREDICTION OF INSTANTANEOUSLY DUMPED DREDGED MATERIALS

By

L. R. Davis
Freshwater Division
Corvallis Environmental Research Laboratory
Corvallis, Oregon 97330

and

G. W. Bowers*
M. K. Goldenblatt
JBF Scientific Corporation
Wilmington, Massachusetts 01887

R-804994

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
CORVALLIS, OREGON 97330

*Presently at E. G. & G., Waltham, Massachusetts

i.a

DISCLAIMER

This report has been reviewed by the Corvallis Environmental Research Laboratory, U.S. Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

Effective regulatory and enforcement actions by the Environmental Protection Agency would be virtually impossible without sound scientific data on pollutants and their impacts on environmental stability and human health. Responsibility for building this data base has been assigned to the EPA's Office of Research and Development and its 15 major installations, one of which is the Corvallis Environmental Research Laboratory (CERL).

The primary mission of the Corvallis Laboratory is research on the effects of environmental pollutants on terrestrial, freshwater and marine ecosystems; the behavior, effects and control of pollutants in lake and stream systems; and development of predicted models on the movement of pollutants in the biosphere.

This report describes the procedure for using a computer model that predicts the fate of instantaneously dumped dredged material into a water column and presents a series of workbook tables to be used for quick approximate answers to dredged material disposal problems. The work was partially done by JBF Scientific under EPA Grant No. R-804994.

Thomas A. Murphy
Director, CERL

ABSTRACT

This manual describes the operation and use of a computer model developed by Koh and Chang, modified in 1976 for the Corps of Engineers and further updated by JBF Scientific Corp., that predicts the physical fate of dredged material instantaneously released into a water column. The model predicts the spatial distribution of various components of the dumped material as a function of time. Outputs include material concentration and position while in the water column, and material mound height and concentration after bottom impact.

Included in this report are a description of the model's structure, a complete explanation of its input/output formats, and in addition, the model has been run for a matrix of input conditions. Both the input and output of these runs are presented as tables in dimensionless form. These working tables can be used to approximate the fate of dredged material for a wide variety of input conditions without requiring the user to actually run the model. Several examples showing how these tables can be used are also given.

The first phase of this work was done by JBF Scientific under sponsorship of the U.S. Environmental Protection Agency through Grant R-804994. The workbook portion of this report was done in-house at the EPA Corvallis Environmental Research Laboratory. The report covers the period from August 1976 to July 1979.

CONTENTS

Foreword iii

Abstract iv

Figures vi

Tables vii

1. Introduction 1
2. Model Description 3
3. Program Format 13
    A. Complete INPUT/OUTPUT Format 13
    B. Simplified INPUT/OUTPUT Format 61

4. Description of Workbook Tables and Examples 78
    A. General Description 78
    B. Examples of Use 83
    C. Workbook Tables 93

References 131

Appendix A - Computer Listing 132

FIGURES

Number	Page
1. Typical long term diffusion grid network	4
2. Velocity option one, representative velocity profile in x direction. Velocity assumed invarient in time and horizontal plane	6
3. Velocity option two, representative velocity profile in x direction. Velocity variable in horizontal plane and time	6
4. Velocity option three, representative velocity profile in x direction. Velocity variable in horizontal plane and time	7
5. Velocity option four, representative velocity profile in x direction. Velocity variable in horizontal plane and time	7
6. Typical dredged material grain size distribution and model representation	9
7. Estimations of settling velocity versus sphere diameter according to Rubey, Jenke, Stokes, Newton and Gibbs	10
8-30 Input cards for long version	14-36
31-46 Input cards for simplified version	62-77
47. Assumed ambient velocity profile for workbook tables . . .	79
48. Definition ellipse for material settled on bottom	82
49. Predicted shape and location of material settled on bottom for example #1	85
50. Predicted shape and location of different types of material settled on bottom for example #2	90
51. Composite shape, location and maximum thickness of material settled on bottom for example #2	91
52. Contour line where thickness is one-half the maximum thickness for example #3	92

TABLES

Number		Page
1-16.	Typical computer output - long version	39
17-18.	Cross-reference tables for workbook - Output table No.'s vs Input variables	93
19-54.	Workbook tables	95

SECTION 1

INTRODUCTION

Guidelines for evaluating applications for permits to dispose of dredged material in a specific aquatic environment require the prediction of the effects of the proposed discharge program. Because rigid rules cannot be applied generally, it is most desirable to provide local and regional regulatory authorities with a definite set of analytic procedures. One element of such a set of procedures is the standard elutriate test. Another desirable element is a mathematical model which predicts the fate of the discharged material under specific conditions.

Currently, there exist a number of mathematical models to describe the fate of dredged material after discharge. The model described in this manual was originally developed by Koh and Chang in 1973 (1).

The original model has been modified considerably since its inception. Most of these modifications were made for the U.S. Army Engineer Waterways Experiment Station (WES) by Tetra Tech, Inc. (2). Consequently, the model JBF has modified and is presenting in this manual is significantly different from the original 1973 model. For example, the original model attempted to describe three possible methods of dredged materials discharge: Instantaneous dumped release into the water column, hydraulic pipeline or hopper dredge discharge as a jet, and continuous release into the wake of a barge. The WES version is composed of two models: instantaneous dump and jet discharges. This manual describes only the instantaneous dump version. Similarly, the original model used a method of moments to solve the long term diffusion equations. The simplifications implicit in this method were: flat bottom, current invariant over a horizontal plane, and no bounds to the dump area. The current model was updated for estuarine use, and allows bottom bathymetry and estuary bounds as well as spatially time varying current as inputs.

The model predicts the course of dynamic behavior of the discharged material in terms of three different phases: convective descent, collapse, and long-term diffusion. The convective descent phase describes the history of the dumped material from injection into the water column until either neutral buoyancy or bottom impact is reached. During this phase, the material is driven by its initial momentum and negative buoyancy. The next phase commences when either neutral buoyancy is reached or the bottom impact is achieved and the material proceeds to collapse vertically. During collapse the vertical descent of the material is reduced and the predominant velocity of the material is in a horizontal (or parallel to the bottom) plane. Long-term diffusion commences when the cloud spreading velocity due to collapse becomes less than that due to turbulent diffusion, so that material loses its own dynamic character and is driven by ambient fluid dynamics.

The JBF modification to the WES model (3) consisted of tuning input coefficients to a comprehensive set of laboratory tank test data. Empirical equations giving certain coefficients as a function of material cohesiveness (beyond limit) were built into the model. In addition input and output formats were simplified for easier use and clarity.

The primary function of this manual is to describe the operation of the JBF instantaneous dump version of the model. It is not the purpose of this document to describe the mathematical foundation of the computer program. Consequently the manual will describe in great detail the input/output formats of the model, give an insight as to their meaning, explain the procedures necessary to develop the input data and present a series of workbook tables with explanations of use. Formal descriptions of the evolution of the model and its foundation are presented in references 1, 2, and 3.

SECTION 2

MODEL DESCRIPTION

JBF has developed two versions of the instantaneous dump program. Both are similar in mathematical structure and are based on the original WES program (2). The differences are in input/output format and program flexibility. The first version has options for handling up to thirteen material components, and modeling the dump location with a large grid network. Comprehensive tabular and graphical output of relevant parameters as functions of time is available. Since its input/output formats are long and tedious and because the program requires a large amount of computer storage, a second or "modified" version was developed which has slightly less flexibility but simpler input/ output formats and requires significantly less computer storage. The first program version has an option to simplify input/output formats but does not have an option for reducing its core size requirements.

The instantaneous dump model requires three categories of information as input data: ambient conditions (including bottom topography), material properties and a description of the material location and dynamics at discharge. Location and dynamics refer to the centroid of the dredged material, as the material is assumed to be a hemispherical cloud of uniform concentration. Ambient fluid properties consist of density and velocity profiles. Bottom topography requires input of bathymetry, digitized to conform to the long-term diffusion grid network. Material properties include aggregate density, voids ratio, liquid limit and radius of the bulk cloud; and density, concentration, fall velocity and voids ratio of the component solids. The material location and dynamics required as input are cloud centroid position in the long term grid, and centroid velocity at release. Also required as input are the initial time of drop, the duration of the simulation, and the long-term integration time step size.

Program outputs include individual component solid concentrations and position, velocity and concentration of the aggregate material cloud as a function of time after the drop. During the stages where solid components begin to settle out of the cloud, program outputs include the quantity and mound height of the material that has settled to the bottom during passive diffusion.

The program requires defining the geometry of the estuary into which the material is to be dumped. This is done by specifying the bathymetry of the estuary. The program is designed to model an area by specifying physical parameters at discrete grid points. That is, the area to be examined is divided into rows and columns. The intersection of a row with a column is a grid point at which depth and position are specified. Figure 1 represents a typical grid for an irregular boundary. By specifying DX and DZ, the position of each grid point from the origin is fixed. The values of DX and DZ selected will dictate the number of grid points necessary to define a given boundary. For example, if the value of DX is halved, twice the number of grid points will be necessary to define the same special distance.

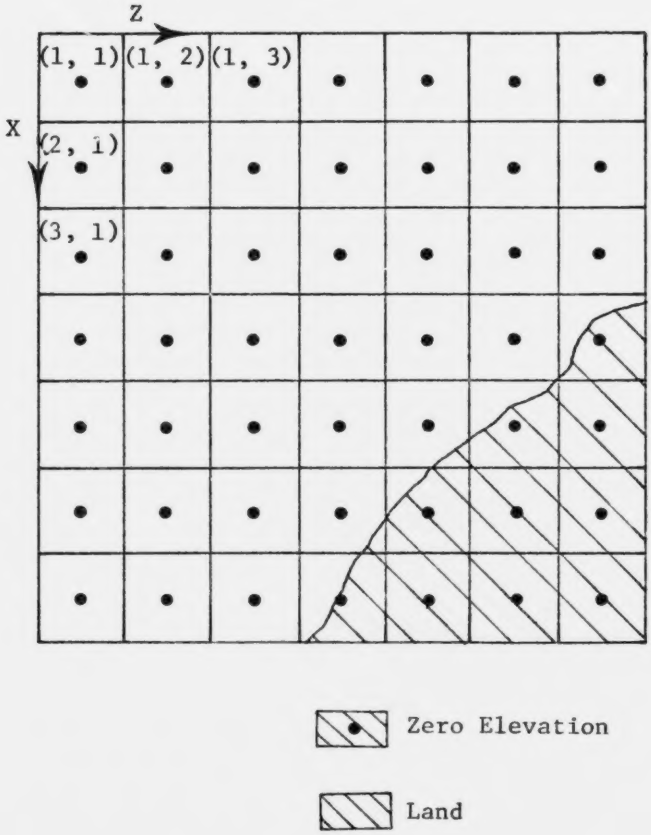

Z
X
(1, 1)
(1, 2)
(1, 3)
(2, 1)
(3, 1)
Zero Elevation
Land

Figure 1. Typical Long Term Diffusion Grid Network

The program defines the geometry of the estuary by specifying the vertical position of the grid points relative to the water surface: for example, zero depth for a grid point represents a land boundary. In addition to defining the estuary's geometry, the grid also serves to define the points at which long-term diffusion calculations are performed.

Having defined the estuary with the grid network, the drop position within the grid must be specified. It is not necessary to position the material drop at a grid point. Rather the material should be positioned close to, if not at, the center of the grid if an open water drop in zero ambient velocity is being simulated, since, for computational reasons, it is desirable to avoid having the dropped material reach the grid boundaries. Similarly, simulation of a drop into an ambient current will require some prior insight into potential dynamics, as the initial placement should allow the cloud to convert into the center of the grid to maximize utility in the long-term diffusion phase. The ambient fluid density and velocity profiles must also be defined. The density profile is defined (independently of the grid network) in depth only and, consequently, must be defined for the deepest point in the estuary. The program is capable of handling the specification of ambient density at up to ten individual depths.

There are four options for specifying the ambient velocity field. The simplest assumes a constant depth environment and that the two orthogonal velocity profiles vary only with depth: ambient velocity does not vary in either a horizontal plane or time (Figure 2). The inputs for this velocity option are specified on a single input card. The second option is not restricted to a constant depth and allows for the velocity field to be varied both in the horizontal plane and time (Figure 3). It does, however, require that the velocity profile be averaged in the vertical direction and that the velocity field satisfy the following constraint (continuity equation):

$$\frac{\partial}{\partial X}(hU_h) + \frac{\partial}{\partial Z}(hW_h) = 0$$

where:

h = water depth (ft)

U_h = average velocity in X direction at h (ft/sec)

W_h = average velocity in Z direction at h (ft/sec)

Inputs from this option are specified on a mass storage device such as a magnetic tape for each long-term time step. Reference 3 presents a computer program used to define an example of this option.

The third velocity input option also requires the input to be vertically averaged velocities at each grid point as a function of long-term time step. The program then assumes a logarithmic profile for the velocity which, when integrated, will have the same vertical average velocity (Figure 4). Inputs for this option are also specified on a storage device at each grid point as a function of long-term time step.

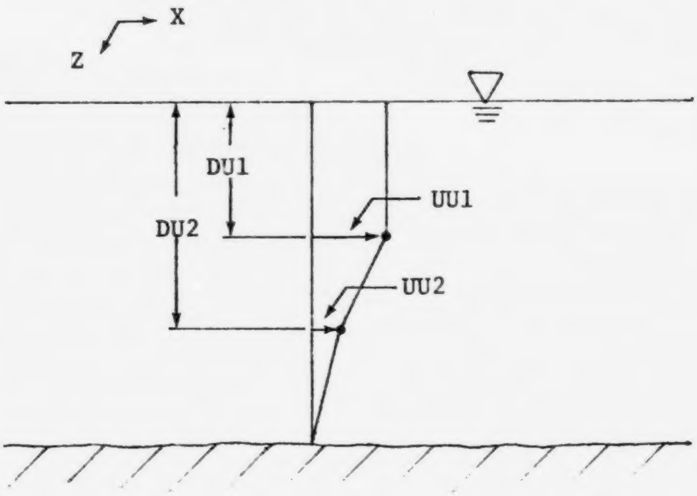

X
Z
DU1
DU2
UU1
UU2

Figure 2. Velocity option one, representative velocity profile in X Direction. Velocity assumed invariant in time and horizontal plane.

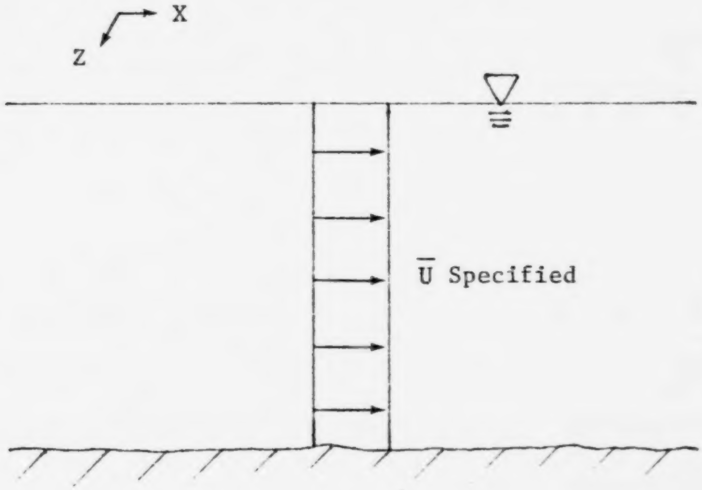
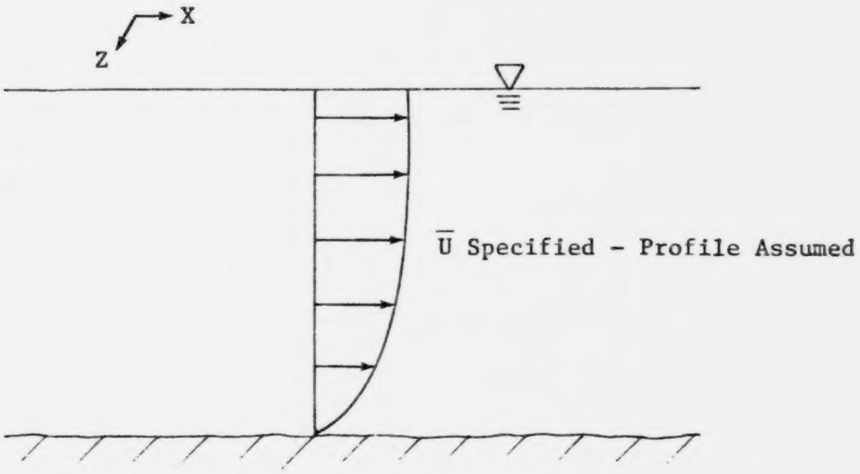
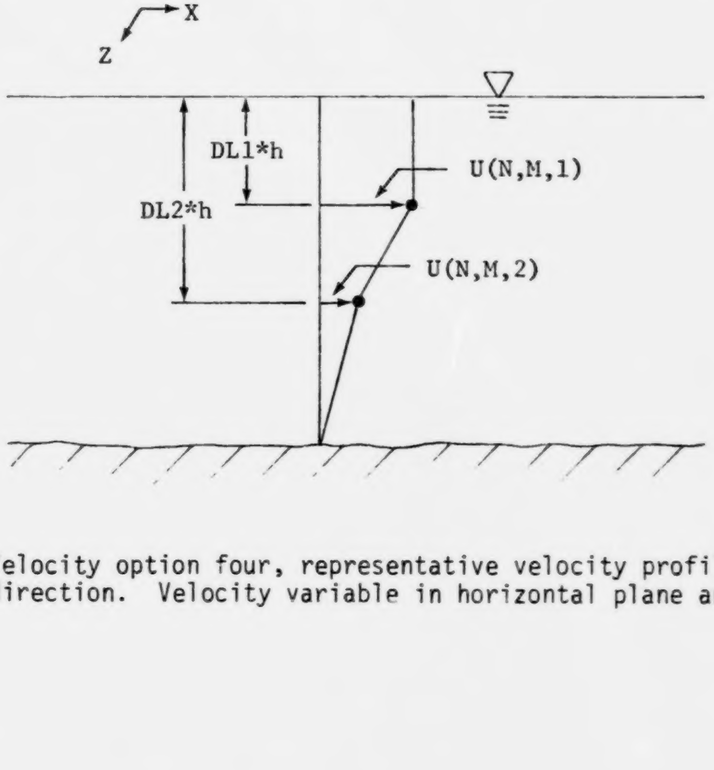

X
Z
$\overline{U}$ Specified

Figure 3. Velocity option two, representative velocity profile in X direction. Velocity variable in time and horizontal plane.



X
Z
$\overline{U}$ Specified - Profile Assumed

Figure 4. Velocity option three, representative velocity profile in X direction. Velocity variable in horizontal plane and time.



X
Z
DL1*h
DL2*h
U(N,M,1)
U(N,M,2)

Figure 5. Velocity option four, representative velocity profile in X direction. Velocity variable in horizontal plane and time.

The last velocity option available is representative of the velocity field to be expected in a stratified estuary and is again supplied from a storage device. At each grid point, ambient velocity is specified at two depths in a similar manner as was done in the first velocity option (see Figure 5). The velocity field at each grid point must satisfy the following continuity equation:

$$\frac{\partial U}{\partial X} + \frac{\partial W}{\partial Z} = 0$$

where:

X, Z = horizontal axes

U, W = X and Z velocities

As a consequence, the input data for this velocity option requires a great deal of effort to prepare.

For velocity input options two, three, and four, each input tape (or equivalent storage device) should contain sufficient data for one 25-hour tidal cycle. The cycle is assumed to repeat itself and, consequently, the simulation can be arbitrarily started at any point in the tidal cycle and continued for any duration desired.

Material geometry and disposition at discharge must be specified. This is performed by defining the size (radius), and centroidal position and velocity of the material at discharge. Since the program assumes that the discharged material is initially in the shape of a hemisphere, the hemisphere's radius must be estimated at the time of discharge by equating the volume of the dredged material in the barge to $2/3\pi r^3$ and solving for the radius, r. Centroidal velocity for the hemisphere is the velocity of the material relative to the barge at time of release. Lastly, the position of the hemisphere's centroid at discharge can be estimated by setting it equal to the center of the dredge material in the barge relative to the surface of the water.

The program also requires a description of both the bulk properties of the aggregate material and the properties of the individual particles that compose the dredged material. These properties include density, voids ratio, liquid limit, concentration and fall velocity. It was determined (4) that three representative grain sizes, defining three solid component fall velocities, are sufficient to categorize a typical dredged material.

Figure 6 is a gradation curve for a typical dredged sediment. The curve can be divided into three segments with the breakpoints at 33.3 percent and 66.7 percent by weight. The median grain size in each of these segments is then used to describe that segment's grain size distribution.

The program required as input the individual solid component fall velocities which can be determined from the material grain size distribution. For example, Figure 7 is a typical graph of particle diameter versus settling velocity (from reference 5). The curves due to Janke, Rubey, Stokes and Newton are proposed equations. The curve due to Gibbs is based on gathered

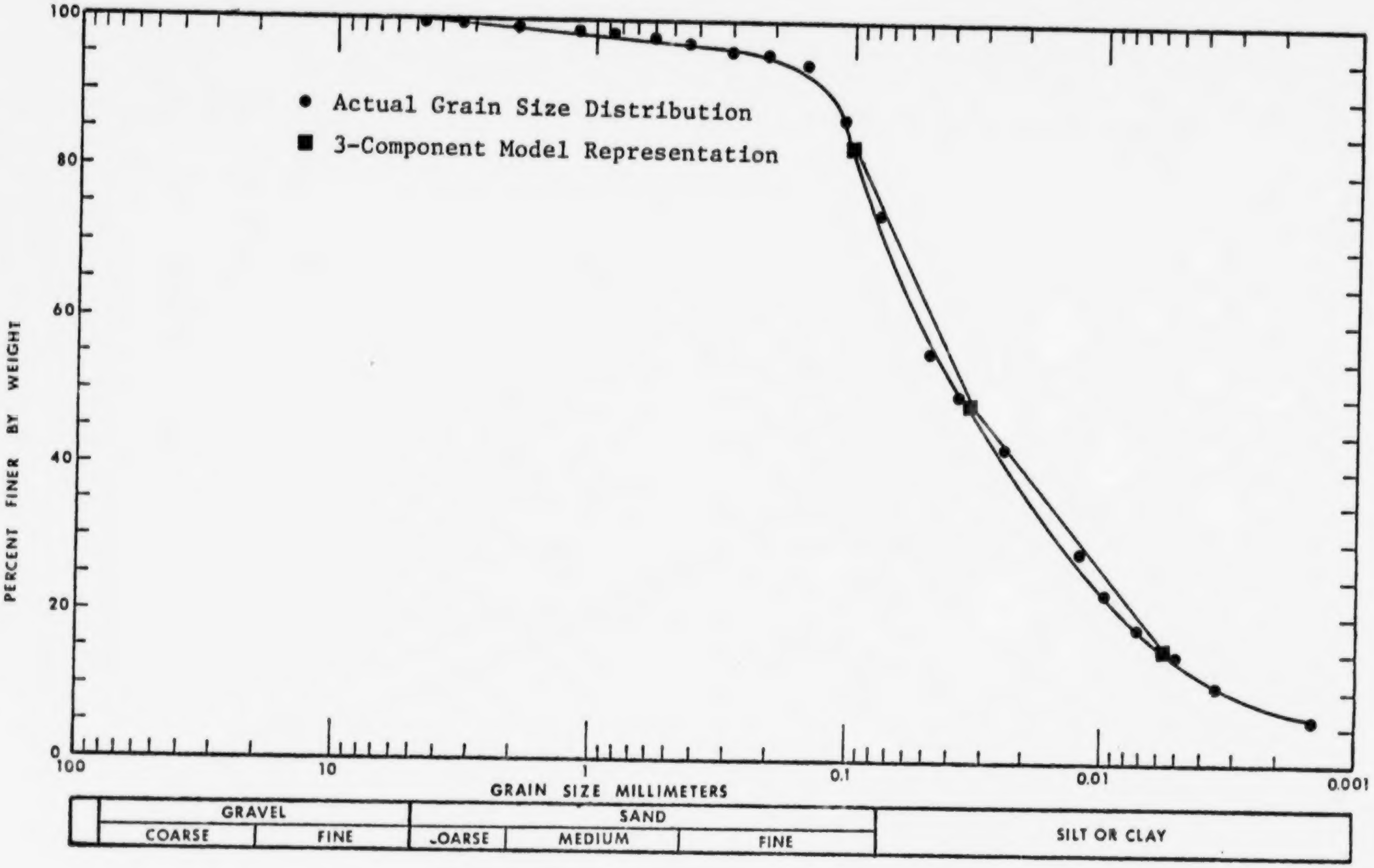


Figure 6. Typical dredged material grain size distribution and model representation.

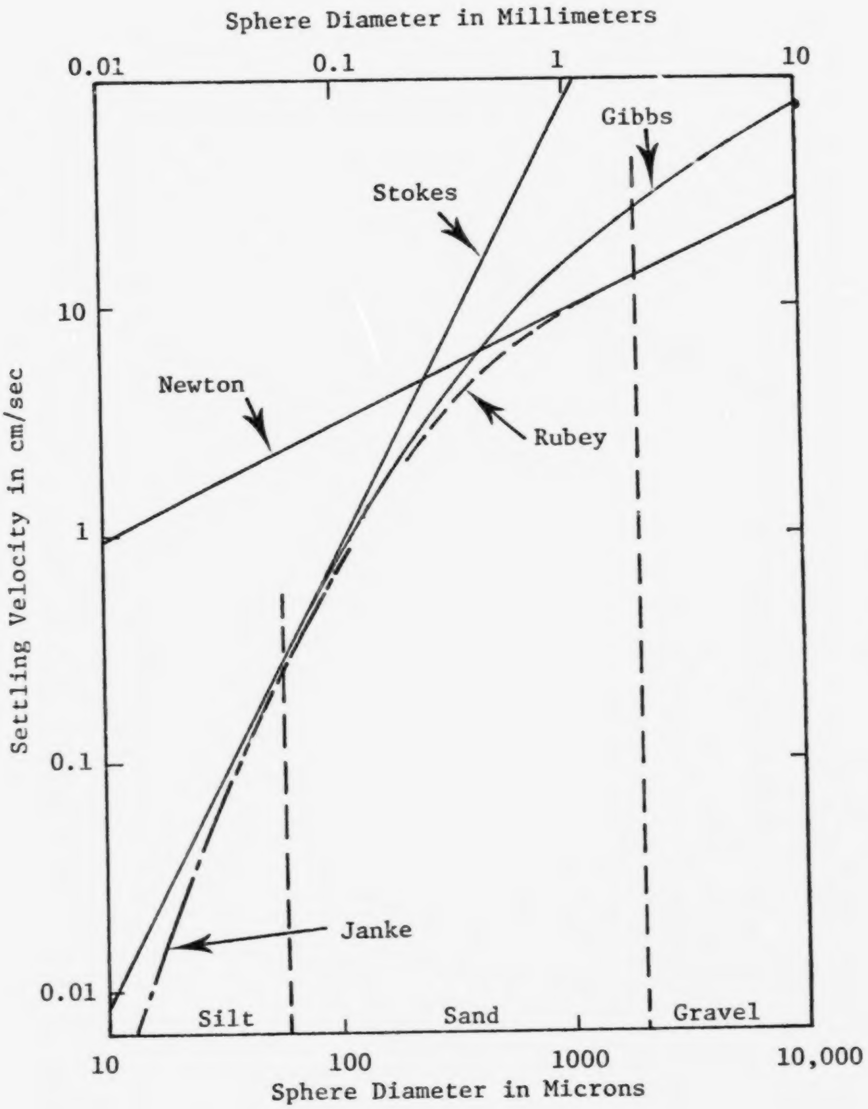


Figure 7. Estimations of settling velocity versus sphere diameter according to Rubey, Jenke, Stokes, Newton, and Gibbs. (Source Ref. 5)

from observations of spheres settling in a column of water. Using an average grain size as determined from Figure 6, Figure 7 can be used to determine a component's fall velocity. For a complete explanation of fall velocity as it relates to various solid components, see references 5 and 6.

The liquid limit of a material is the moisture content (expressed as percent of dried material) at which the material just begins to flow when lightly jarred (see reference 5 for a complete description of how to calculate a material's liquid limit). Liquid limit will vary with the grain size, organic content, and minerology of the sediment particles. Typical volumes range from 40-120%.

The volume concentration, sv, of a dredged material can be expressed:

$$sv = \frac{1}{1 + (\frac{1}{sw} - 1)\frac{\gamma s}{\gamma H_2O}}$$

where: sv = material concentration, volume ratio (FT^3/FT^3)

sw = material concentration, weight ratio (percent solids)

γs = density of solid (lb/FT^3)

γH_2O = density of fluid (lb/FT^3)

Similarly the voids ratio of a material can be expressed:

$$n = 1 - \frac{\gamma s}{S.G._{solids} \cdot \gamma H_2O}$$

where: n = voids ratio

γs = dry density of solids (lb/FT^3)

γH_2O = density of entrained water (lb/FT^3)

(For further information on calculating n see reference 5)
A typical value of voids ratio is 0.78.

The output of the program describes the location, velocity, and concentration of the material as it descends and spreads in the water. This information is divided into three phases: convective descent, collapse, and long-term diffusion. The long version of the computer output allows as an option a detailed printout of information concerning dynamics simulated in the program. The program will always terminate when the final time specified is reached. However, when all the effluent has dropped out of the water column, the height and accumulated solid volume of the material on the bottom remains constant.

SECTION 3

PROGRAM FORMAT

The computer simulation has two format options. The long version allows for complete flexibility in setting up the problem to be simulated, the output format and the coefficients to be used in the options. It requires a thorough understanding not only of the process being modeled but of many of the equations used in the program and the underlying assumptions used in their development. The short version option eliminates some of the program's flexibility but significantly reduces the amount of input data required of the user and consequently is much simpler and cheaper to use. This chapter will explain the use of both versions.

A. Complete Input/Output Format (long version)

The input sequence is initiated by specifying the type of format desired. Since for this case a complete set of output data is desired, the value of KAYMAX on the first card should be set to 1 (Figure 8). This in turn dictates to the program that a complete set of input/output data will be forthcoming.

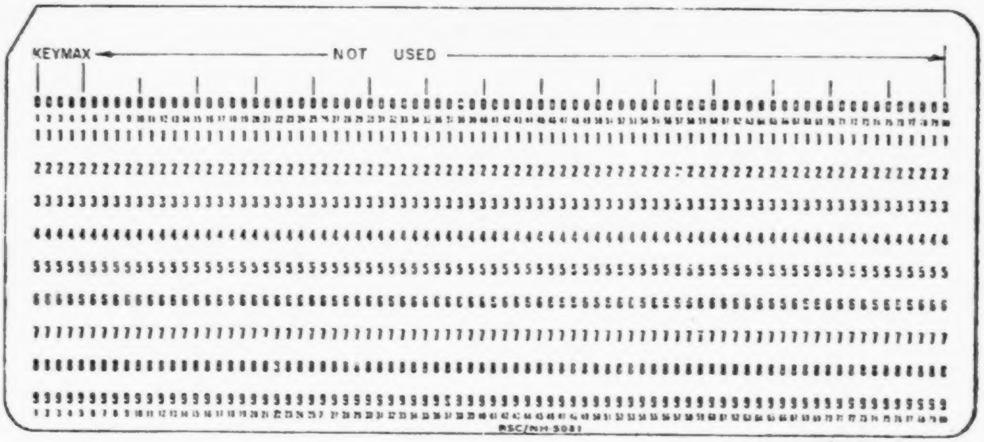
Figures 8 to 30 represent the input cards and parameters required to execute a run of the long version of the program, and complete definitions of the variables specified on the input cards.

The program's output is in two stages. The first stage prints out a summary of the input parameters and the key parameters set internally by the program. This allows for a verification that the input data was correctly submitted. The second stage is the presentation of computational results and is divided into three phases: convective descent, collapse and long-term diffusion. Each phase has important parameters concerning the dynamic behavior of the dredged material listed as a function of time from the start of the run.

Figures 28 through 30 represent cards that are specified only when the user desires to over-ride various coefficients set internally in the program. Because it is not anticipated that the typical user will desire to do so, an in depth discussion of the ramifications of modifying these numbers will not be presented in this users manual. For a complete discussion as to the significance of these numbers the user is referred to references 2, 3, and 4.

Table 1 is a reproduction of a typical first stage print-out summary of input data. All these parameters have been previously defined in Figures 8 to 30.

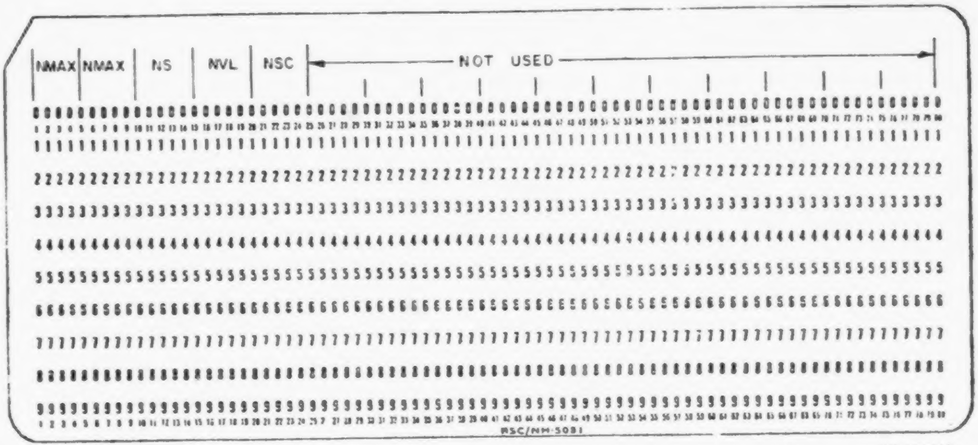
The first output of the second stage is a coded array which indicates the geometry of the estuary to be modeled. This array is inserted in the first stage output immediately after the depth grid, and is shown in Table 2. A value of 1 in a grid point indicates that it represents a part of the water column being modeled. A value of 2 represents a zero depth for the water column at that grid point and is representative of a physical boundary point (i.e. land). A value of 3 represents the boundary of the grid matrix being


KEYMAX
NOT USED
RSC/NH 5081

Format (I5)

VARIABLE	DEFINITION
Keymax	Flag which specifies desired input/output format. KEYMAX = 1 specifies complete format option and is used when using the long program version

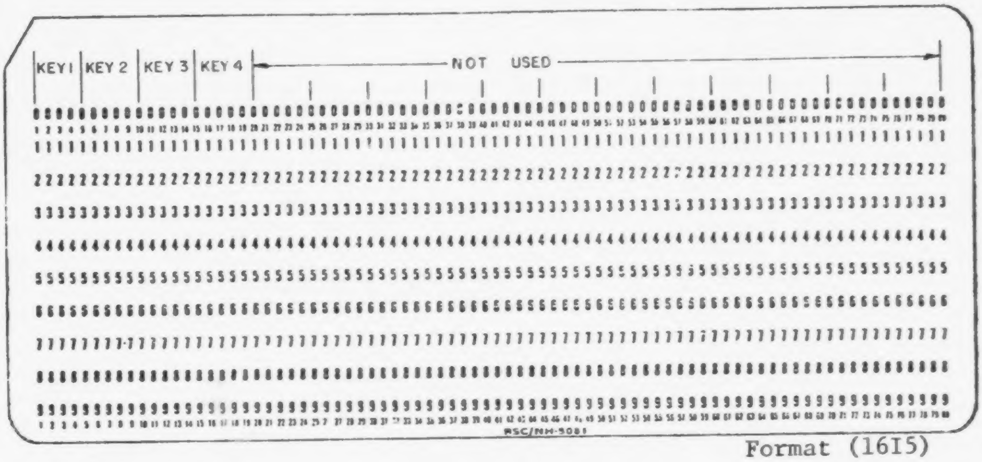
Figure 8. Input Card Number One



Format (16I5)

VARIABLE	DEFINITION
NMAX	Array size in Z direction ($NMAX<31$)
MMAX	Array size in X direction ($MMAX<31$)
NS	Number of dredged material solid components ($NS\leq 12$)
NVL	Number of velocity array levels ($0\leq NVL\leq 2$)
NSC	Maximum number of transitional levels allowed between short and long term models. For the typical user a value of 20 is recommended.

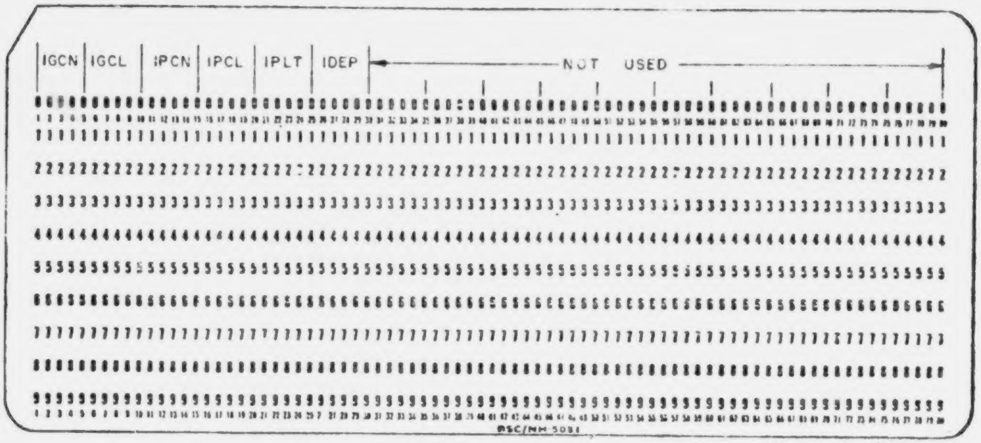
Figure 9. Input Card Number Two



Format (16I5)

VARIABLE	DEFINITION
KEY1	The option exists to redefine various equation coefficients in the model. This option is only of value to those familiar with the program and the ramifications of varying these coefficients. For a complete examination of these coefficients and their application see reference 2. If KEY1 equals 1 no action is taken. If KEY1 equals 2 the user is required to supply these coefficients.
KEY2	The program will cease execution at the end of the convective descent, dynamic collapse or long-term diffusion if KEY2 equals 1, 2 or 3 respectively.
KEY3	If long-term diffusion for the fluid component is desired set KEY3 equal to 1. Otherwise set KEY3 equal to zero.
KEY4	If repeated runs are to be made and user desires to specify descent and collapse time steps (DT) KEY4 should be set to 1. Otherwise KEY4 should be set to zero.

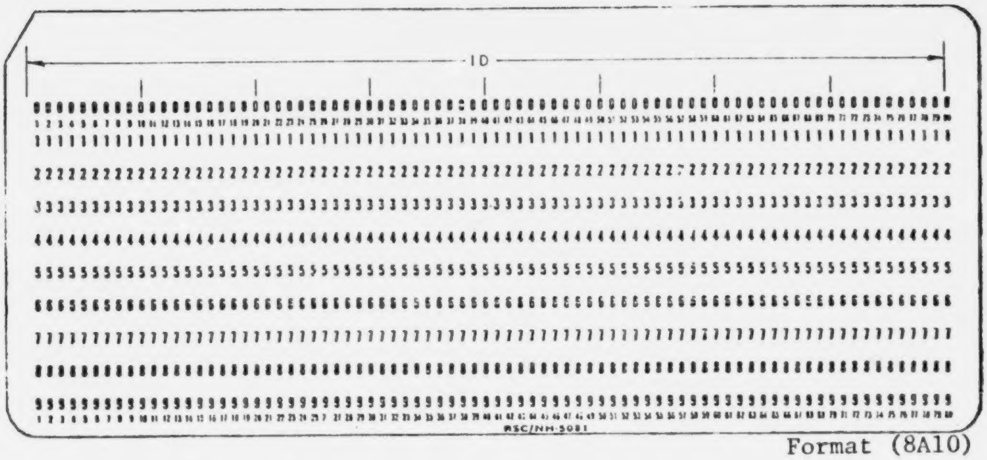
Figure 10. Input Card Number Three



Format (16I5)

VARIABLE	DEFINITION
IGCN	A value of zero will eliminate graphs of convective descent while a value of 1 will result in one extra graph and a value of 2 in two extra graphs.
IGCL	A value of zero will eliminate all graphs of the dynamic collapse phase while a 1 will result in one graph.
IPCN	A zero will eliminate tabular output from the convective descent phase while a 1 will result in the tabular data being printed.
IPCL	The same as IPCN except for the collapse phase.
IPLT	A value of zero will result in the long term results being printed at 1/4, 1/2, 3/4 and 4/4 of the simultaneous stop time. Otherwise the long-term diffusion results will be printed IPLT times for IPLT less than 13.
IDEP	If IDEP equals 1 an NMAX x MMAX constant depth array is assumed with a depth H. If IDEP equals zero array depth parameters are required.

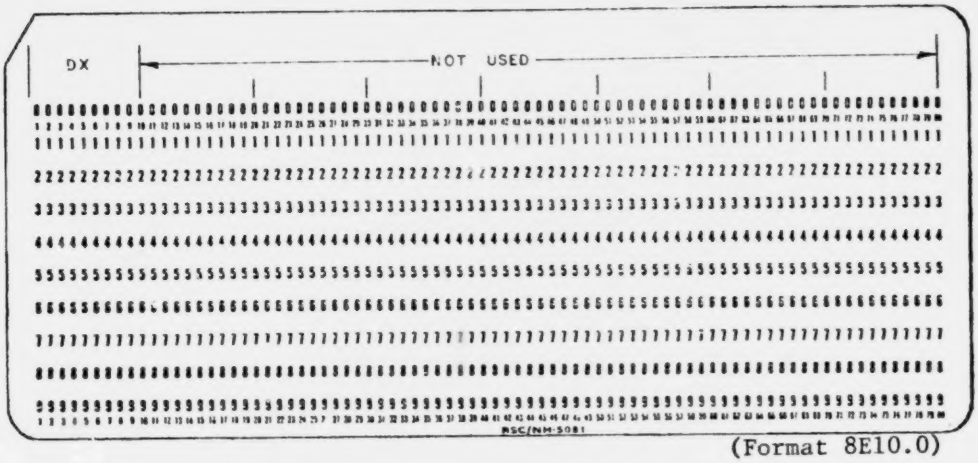
Figure 11. Input Card Number Four



Format (8A10)

VARIABLE	DEFINITION
ID	Alphanumeric run identifier. All 80 columns can be used to describe the run being made. Symbols can be either numeric or alphabetical.

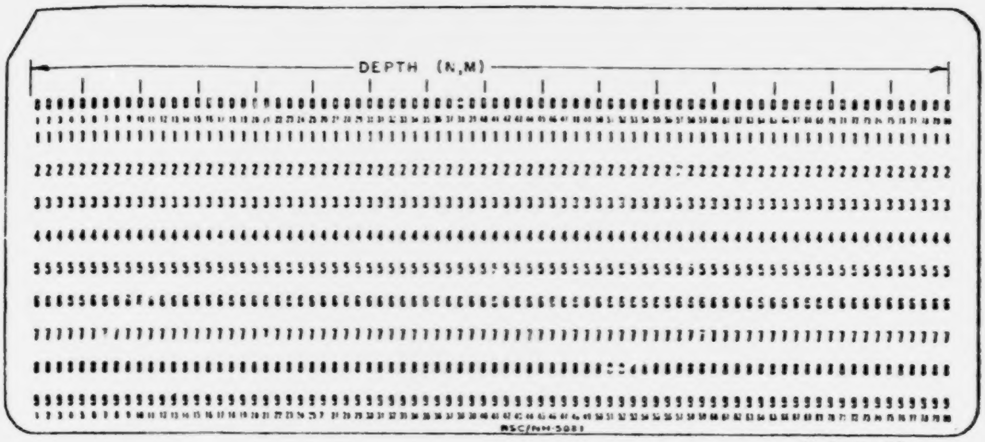
Figure 12. Input Card Number Five



(Format 8E10.0)

VARIABLE	DEFINITION
DX	Grid space size (see Figure 1). The grid spacing is assumed symmetrical in the X and Z directions and as a result the value of DZ is specified by specifying DX. DX is defined in feet.

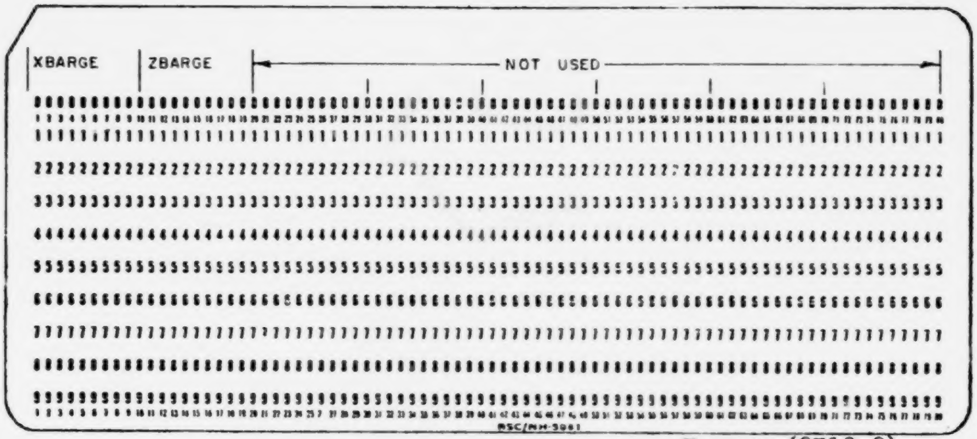
Figure 13. Input Card Number Six



Format (16F5.0)

VARIABLE	DEFINITION
DEPTH(N,M)	Depths of grid point N,M. The grid is defined first by row and then by column. If a grid greater than 16 by 16 is specified the Z grid points in the first row (x grid point 1) from 17 to 31 will be defined on a second input card. After all the Z grid points in the first row have been defined the Z grids points in the second row will be defined in the next input card(s). This will continue until the entire array is filled. Thus for a 31 x 31 array 62 input cards will be necessary (two to describe each row in the grid). Depth is defined in feet. If IDEP equals one the program will assume a constant depth estuary and only H = DEPTH(1,1) need be specified in columns 1 through 5.

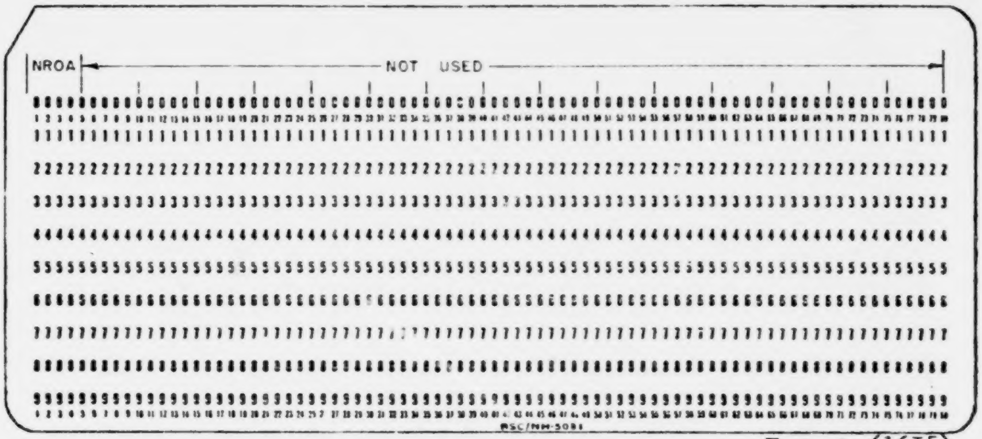
Figure 14. Input Card Set Number Seven



Format (8E10.0)

VARIABLE	DEFINITION
XBARGE	X-coordinate of barge at time of discharge. This coordinate is measured from the grid point 1,1 (see Figure 1) and does not have to be at a grid point itself. XBARGE is defined in feet.
ZBARGE	Z-coordinate is measured from the grid point 1,1 (see Figure 1), and does not have to be at a grid point itself. ZBARGE is defined in feet.

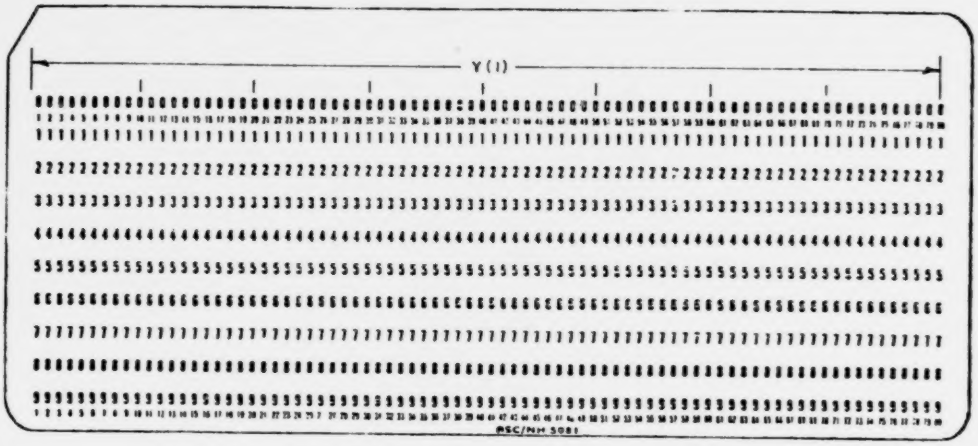
Figure 15. Input Card Number Eight



Format (16I5)

VARIABLE	DEFINITION
NROA	Number of depths at which ambient density is specified (NROA$\leq$10).

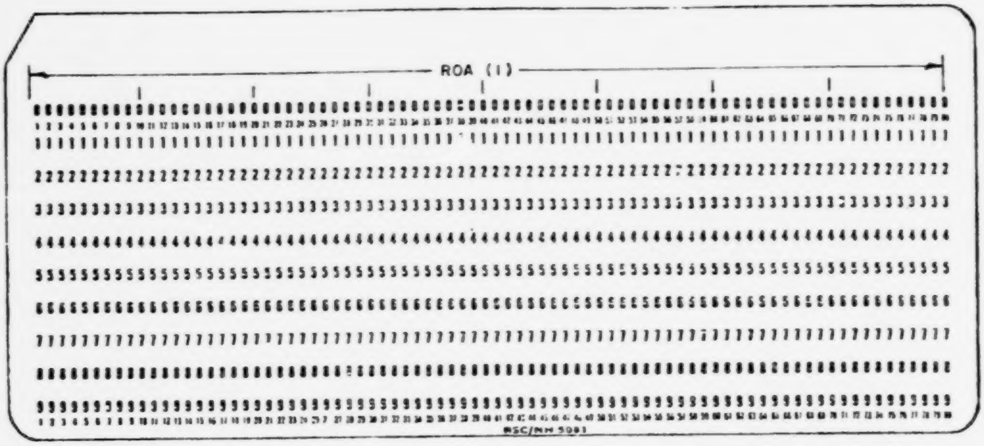
Figure 16. Input Card Number Nine



Format (8E10.0)

VARIABLE	DEFINITION
Y(I)	Depths at which density is defined and the quantity of Y(I) must be equal to NROA. The greatest depth in the drop zone must be equal to Y(NROA). Since (I) can vary up to 10 a second input card will be necessary to define Y(9) and Y(10). Y(I) is defined in feet.

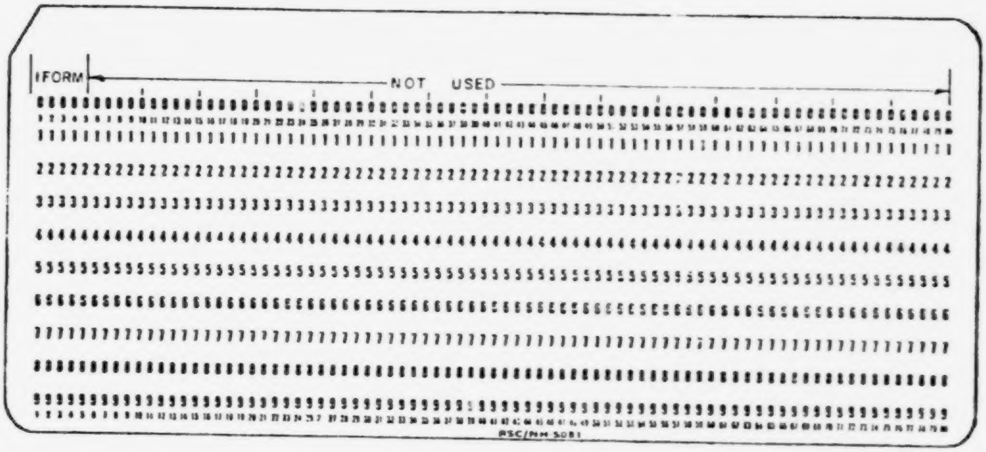
Figure 17. Input Card Set Number Ten



Format (8E10.0)

VARIABLE	DEFINITION
ROA (I)	Density in ambient water at corresponding depths, Y(I). Since (I) can vary up to 10 a second input card will be needed to define ROA(9) and ROA(10). ROA(I) is defined in grams/cc.

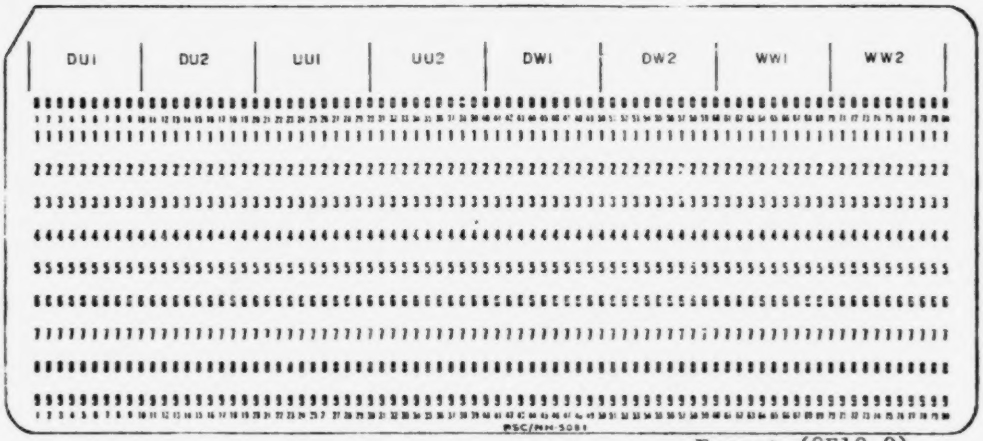
Figure 18. Input Card Set Number Eleven



Format (16I5)

VARIABLE	DEFINITION
IFORM	If IFORM equals one, vertically averaged ambient velocities which are variable in the horizontal and in time, are read from logical unit 7 If IFORM equals 2, the program will generate a logarithmic velocity profile whose average value is that value of velocity read in at each time step. The format is the same as for IFORM = 1, and velocity may vary in the horizontal plane and in time. If IFORM equals three the ambient velocity will be two layers and assumed variable in the horizontal and vertical directions as well as in time If IFORM equals four the two layer ambient velocity profile is assumed constant in both the horizontal plane and time.

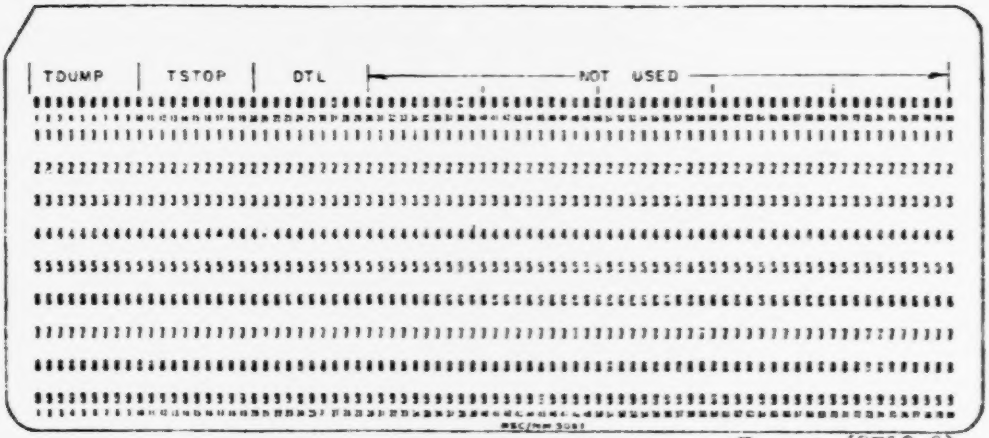
Figure 19. Input Card Number Nine, Simplified Input/Output



Format (8E10.0)

VARIABLE	DEFINITION
DU1	Depth at which upper X velocity is specified (see Figure 2). DUI is defined in feet.
DU2	Depth at which lower X velocity is specified (see Figure 2). DU2 is defined in feet.
UU1	Upper X velocity. UU1 is defined in ft/sec.
UU2	Lower X velocity. UU2 is defined in ft/sec.
DW1	Depth at which upper Z velocity is specified (see Figure 2). DW1 is defined in feet.
DW2	Depth at which lower Z velocity is specified (see Figure 2). DW2 is defined in feet.
WW1	Upper Z velocity. WW1 is defined in ft/sec.
WW2	Lower Z velocity. WW2 is defined in ft/sec.

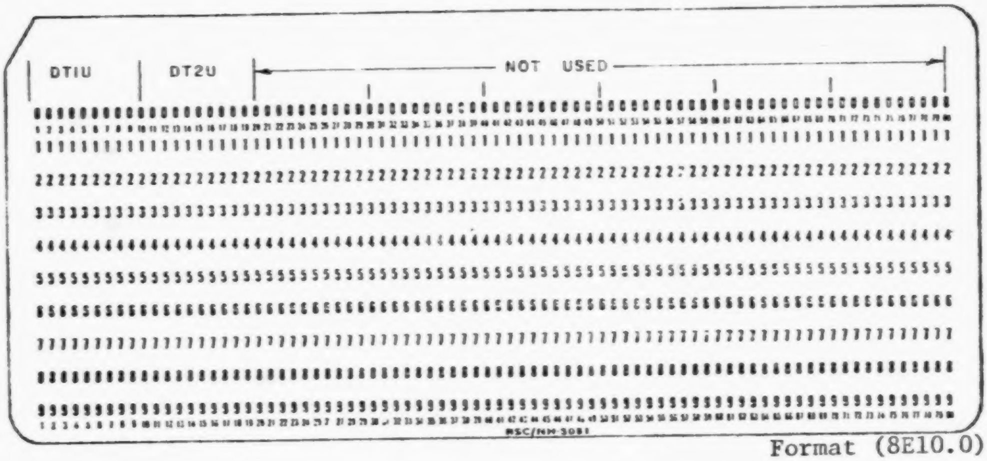
Figure 20. Input Card Number Thirteen (Omit if IFORM $\neq$ 4)



Format (8E10.0)

VARIABLE	DEFINITION
TDUMP	Time of dump relative to the start of tidal cycle (to the nearest DTL seconds).
TSTOP	Duration of simulation (to the nearest DTL seconds).
DTL	Long term integration time increment as well as the time increment between velocity data points. DTL is expressed in seconds.

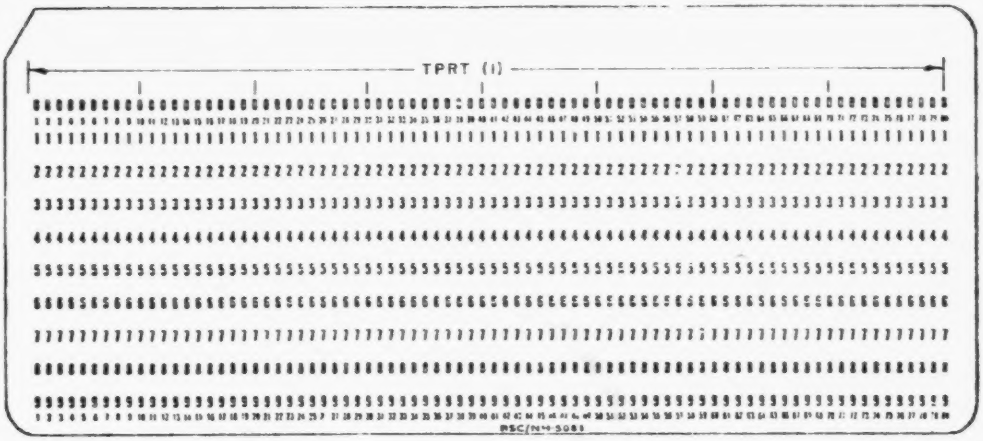
Figure 21. Input Card Number Fourteen


DT1U
DT2U
NOT USED
MSC/NM-3081

Format (8E10.0)

VARIABLE	DEFINITION
DT1U	Convective descent phase time step. DT1U is defined in seconds.
DT2U	Dynamic collapse time step. DT2U is defined in seconds.

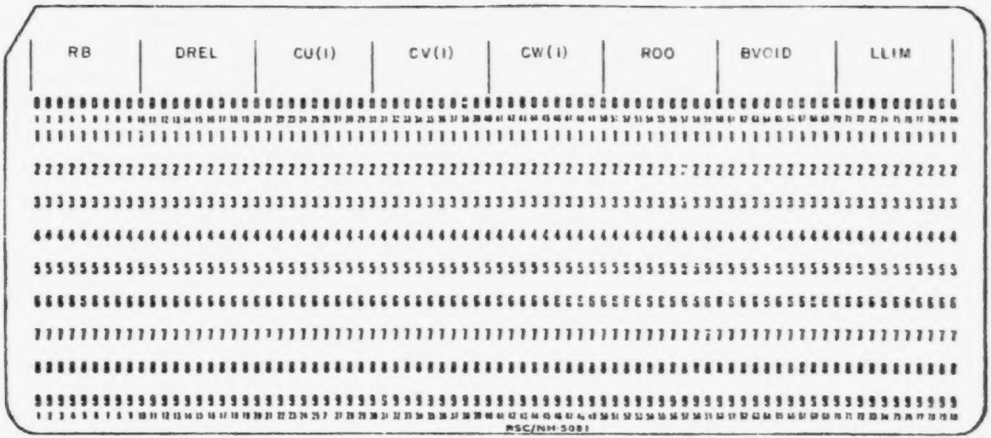
Figure 22. Input Card Number Fifteen (Omit if KEY4 = 0)



Format (8E10.0)

VARIABLE	DEFINITION
TPRT(1)	Long-term diffusion print times. There should be IPLT values of TPRT(I). If IPLT is greater than eight, specify TPRT on a second card.

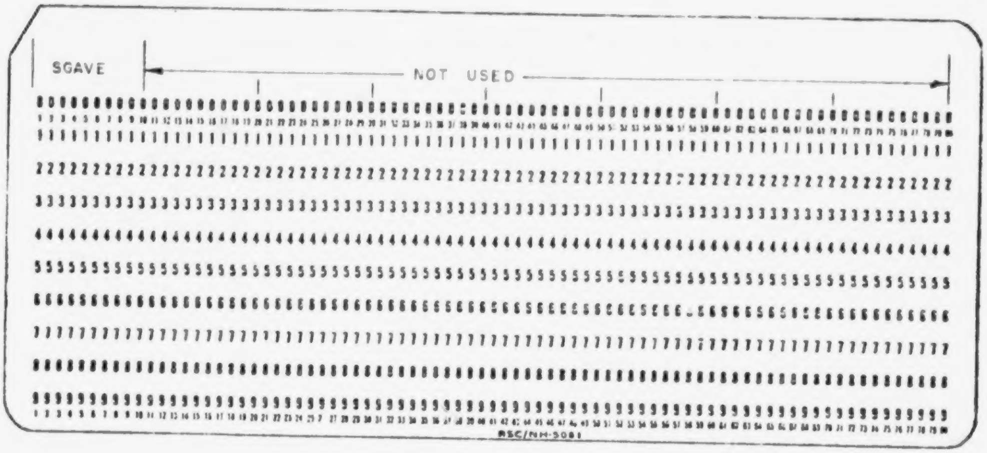
Figure 23. Input Card Number Sixteen (Omit if IPLT = 0)



Format (8E10.0)

VARIABLE	DEFINITION
RB	Radius of hemispherical dredge material cloud at discharge (see page 10). RB is defined in feet.
DREL	Depth of cloud centroid at discharge. DREL is defined in feet.
CU(1) CV(1) CW(1)	Initial velocity of cloud centroid at release in the x,y, and z directions respectively (see page 10). CU(1), CV(1), and CW(1) are defined in feet/second.
ROO	Bulk density of aggregate dredge material. ROO is defined in gm/cc.
BVOID	Voids ratio of aggregate dredge material.
LLIM	Liquid limit of aggregate dredge material.

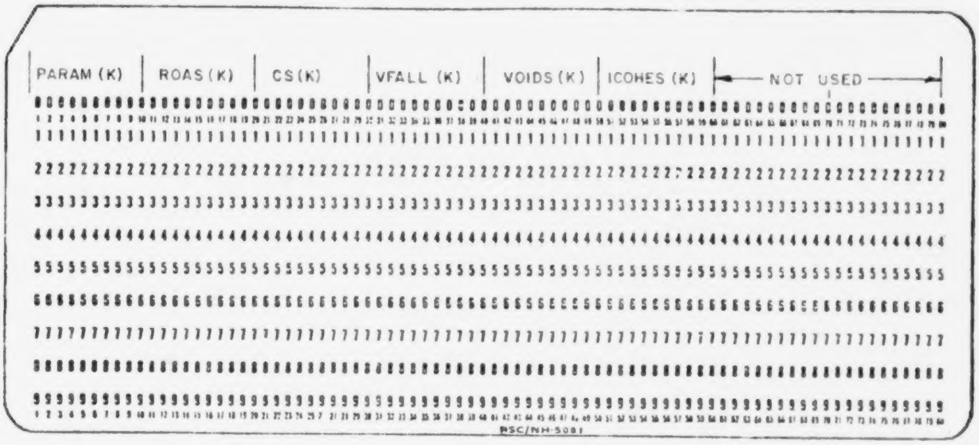
Figure 24. Input Card Number Seventeen



Format (8E10.0)

VARIABLE	DEFINITION
SGAVE	Average Specific gravity for the aggregate dredge material.

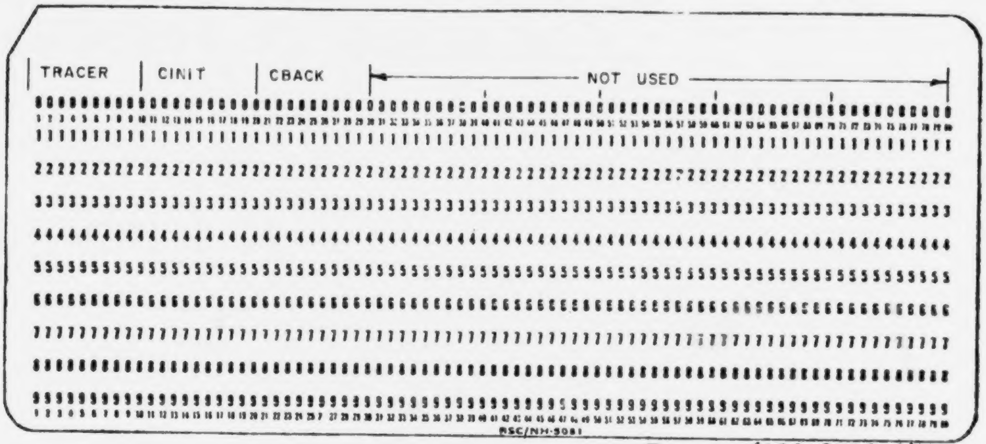
Figure 25. Input Card Number Eighteen



Format (A10, 4E10.0, I5)

VARIABLE	DEFINITION
PARAM(K)	Descriptive identifier for solid component (K). PARAM(K) can be any numeric and/or alphabetical combination.
ROAS(K)	Solid density of solid component (K). ROAS is defined in gm/cc.
CS(K)	Volume concentration of solid component (K) in bulk cloud.
VFALL(K)	Fall velocity of solid component (K). VFALL is defined in ft/sec.
VOIDS(K)	Voids ratio of solid component (K).
ICOHES(K)	If ICOHES equals zero the cohesive model in the long-term diffision phase is bypassed. If ICOHES equals one the long term diffusion phase employs the cohesiveness model.

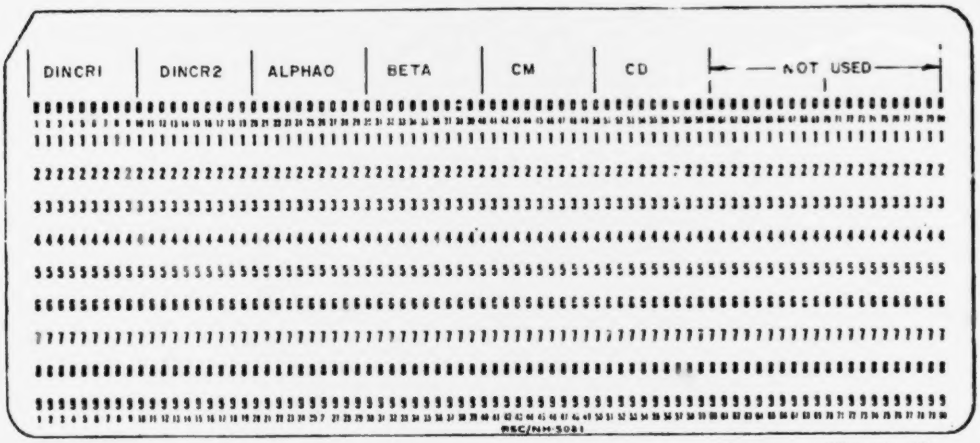
Figure 26. Input Card Set Number Nineteen (Repeat NS times, one for each solid component)



Format (A10,2E10.0)

VARIABLE	DEFINITION
TRACER	Descriptive identifier of tracer in fluid cloud. Can be any numeric and/or alphabetical combination.
CINIT	Tracer concentration. CINIT is defined in mg/liter.
CBACK	Background concentration of tracer in ambient fluid. CBACK is defined in mg/liter.

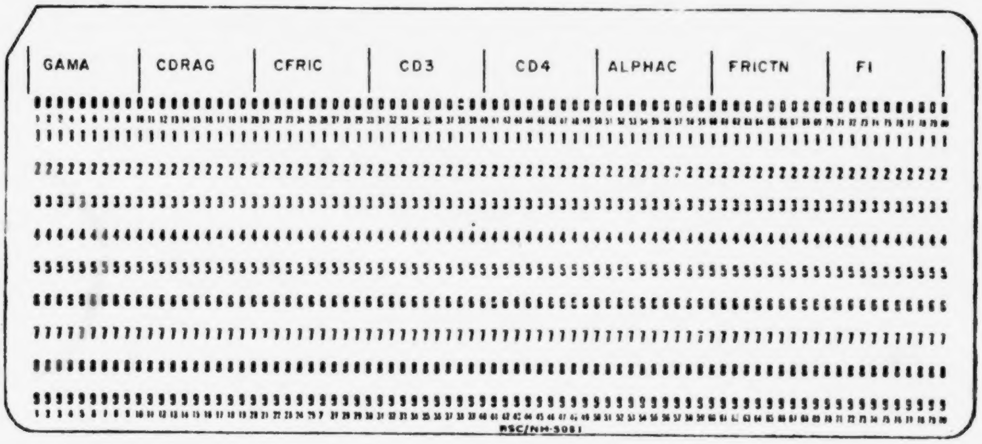
Figure 27. Input Card Number Twenty
(Substitute blank card if KEY3 = 0)



Format (8E10.0)

VARIABLE	DEFINITION
DINCR1	Allows user to influence program's estimation of convective descent time step.
DINCR2	Allows user to influence program's estimation of dynamic collapse time step.
ALPHAO	Turbulent thermal entrainment coefficient.
BETA	Coefficient which influences material settling
CM	Virtual mass coefficient
CD	Drag coefficient

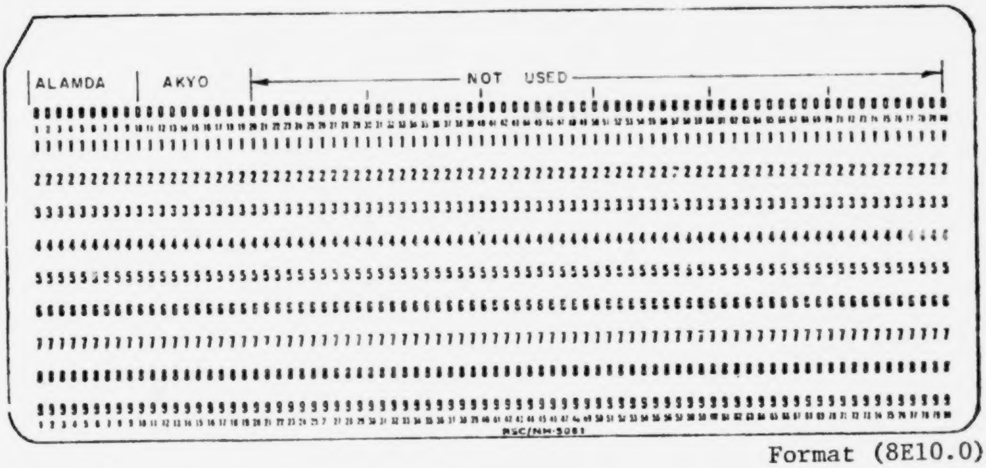
Figure 28. Input Card Number Twenty-One (Omit if KEY1 = 1)



Format (8E10.0)

VARIABLE	DEFINITION
GAMA	Dredge material density gradient coefficient.
CDRAG	Collapse phase form drag coefficient.
CFRIC	Collapse phase skin friction coefficient.
CD3	Ellipsoidal wedge drag coefficient.
CD4	Plate drag coefficient.
ALPHAC	Collapse phase entrainment coefficient.
FRICTN	Coefficient of friction between effluent and estuary bottom.
F1	Collapse phase friction force modifier.

Figure 29. Input Card Number Twenty Two (Omit if KEY1 = 1)



Format (8E10.0)

VARIABLE	DEFINITION
ALAMDA	Horizontal diffusion coefficient dissipation factor.
AKYO	Vertical diffusion coefficient upper limit.

Figure 30. Input Card Number Twenty Three (Omit if KEY1 = 1)

used. Note that the grid network shown is a square with no land boundaries and contains a range of 31 points in both the X and Z directions.

Making computations for the convective descent phase, the program selects a time step (DT) based upon the cloud dynamics. If either the bottom or neutral buoyancy has not been reached in 100 time steps, a second time step is selected and the process repeated. When either the bottom or neutral buoyancy has been reached between 100 to 200 time steps, the program progresses to the next phase. However, if neither the bottom or neutral buoyancy has been reached in 5 of these trials (NTRIAL), the program will terminate.

When the cloud hits the bottom during descent, the variable IPLUNG will change from 0 to 1 if the event occurred in subroutine DUMP, and from 0 to 2 if the event occurred in subroutine COLAPS (Appendix A). However, if the program predicts the cloud will rise off the bottom, IPLUNG will be set to 4. If the material reaches neutral buoyancy before encountering the bottom, the variable NUTRL will be changed from 0 to 1. However, if diffusive spreading is greater than dynamic spreading during this phase NUTRL will be set to 3. Lastly, ISTEP represents the number of time steps needed to either reach neutral buoyancy or the bottom for the associated NTRIAL.

The value of ISTEP for the last NTRIAL listed should be between 100 and 200, as previously mentioned. Table 2 is a representative program printout for these parameters.

The program next prints out a summary of those parameters important in describing the material's dynamics during convective descent, as a function of time. X and Z are the material's horizontal centroidal coordinates with respect to the water surface. U, V, and W are the X, Y and Z velocities of the cloud's centroid. The buoyancy of the cloud is a function of the density difference between the ambient and the material and thus the program prints out DEN-DIF. Next the program lists the radius, diameter and vorticity of the descending cloud. The program assumes that during convective descent, the shape of the material cloud is that of a hemisphere and thus prints out the hemisphere's radius and diameter as a function of time. Vorticity is generated at the cloud's boundaries by sheer forces and is printed out as an indication of the amount of entrainment taking place. The last three parameters printed in this format block are fluid concentration, and solid volumes and concentrations of the individual solid components within the cloud. The fluid concentration is the volume concentration of fluid internal to the cloud, or unity, minus the sum of the concentrations of the individual solid components. The solid-volume is the individual concentration of each solid component multiplied by the volume of the material cloud. Table 3 is a typical representation of the digital output for the convective descent phase.

In addition to the tabular output for the convective descent phase, the program prints out a plot of the material's X, Y and Z coordinates and hemispherical radius as a function of time. The plot has time as the ordinate and the normalized values for coordinates on the abcissa. Normalizing values and a description of symbol definitions for a typical run are shown in Table 4. A typical computer-generated plot of X, Y and Z coordinates and cloud hemispherical radius is shown in Table 5.

Following the plot of the dredged material's position and size during convective descent is a tabular description of the important parameters during collapse. The output is similar to that generated for convective descent with the exception of geometric parameters. Since the collapsing cloud is assumed to be an oblate spheroid rather than a hemisphere as in the convective descent phase, semi-major (BB) and semi-minor (AA) axes are output instead of cloud hemispherical radius. Also, since cloud vorticity is assumed to be zero during collapse, vorticity is eliminated from the program's output. A typical computer output for collapse is shown in Table 6.

Similar to the plots generated for the convective descent phase, the program plots material properties for the collapse phases. These properties include spheroid size (vertical and horizontal) depth and concentration. Definitions and normalization values for material size, concentration and depth are shown in Table 7 while a plot of these parameters as a function of time is shown in Table 8 for a typical simulation. Note the decreasing vertical size and increasing horizontal size of the cloud as it collapses.

For computational reasons, the computer program makes the transition to the passive diffusion stage by creating small clouds of material. These clouds are tracked individually until diffusion causes them to expand to the size of a long-term passive diffusion grid square. They are then injected into the passive diffusion grid. The output for the passive diffusion phase reflects this computational method and is presented for each material present. Table 9 represents the program's descriptive output for the small clouds created for the material called "100-90", representing the coarsest 10% of the sample.

T(sec) is the time at which the new cloud has been created by the program. TX and TZ represent the horizontal position of the clouds with respect to the grid coordinates. TSIDE, TTOP and TTHK are the horizontal dimension, distance from the water's surface and thickness of the associated cloud. TMASS is the total component mass in the small cloud. TEMAS represents an attempt to allow for the entrainment into the small cloud of material in the ambient environment. It is not a currently executed option.

NEWT and LAST are, respectively, the time step at which the small clouds are injected into the long-term passive diffusion phase and the time step at which they were first created.

During the course of long-term diffusion, a summary of the material suspended in the water column, as well as the amount of material accumulated on the bottom, is printed. This can be seen in Table 10. Printout of this table will terminate when all the material has settled out of the water column.

The program presents a graphic summary of each component's position and thickness as a function of time and grid location. Tables 11 and 12 are typical of this type of output. The program also prints out a graphic summary of the amount of each component that has settled on the estuary bottom, as well as the concentration of the material remaining in the water column (Tables 13 and 14). At the final print time, the program prints the total accumulation and thickness of material settled on the bottom. Tables 15 and 16 are a typical example of total bottom accumulation and thickness respec-

TABLE 1. COMPUTER GENERATED INPUT SUMMARY

```
 STORAGE ALLOCATION PARAMETERS FOLLOW...
 NMAX MMAX    NS  NVL  NSC     NEED
  31   31      4   1   20        0
```

(1 of 7)

TABLE 1. COMPUTER GENERATED INPUT SUMMARY (Cont.)

```
FATE OF DREDGED MATERIAL DEPOSITED IN AN ESTUARY BY DUMPING

EXECUTION PARAMETERS FOLLOW...
KEY1  KEY2  KEY3  KEY4  IGCN  IGCL  IPCN  IPCL  IPLT   IDEP
  2     3     0     0     1     1     1     1     0     1
    VERIFICATION RUN -- FALL RUVER SILT -- 500 PCM

NUMBER OF LONG TERM GRID POINTS IN Z-DIRECTION (NMAX) =  31

NUMBER OF LONG TERM GRID POINTS IN X-DIRECTION (MMAX) =  31

GRID SPACING (DX) =      2.00000
```

(2 of 7)

TABLE 1. COMPUTER GENERATED INPUT SUMMARY (Cont.)

```
BARGE COORDINATES...
XBARGE (FT) =     30.00        ZBARGE (FT) =     33.00

                     ---AMBIENT CONDITIONS---

      DEPTH (FT)          0.           4.000
AMBIENT
DENSITY (GM/CC)         1.000        1.000

 INTERPOLATED DEPTH AT DUMP COORDINATES, H =     4.000      FT.
```

(3 of 7)

Reproduced from
best available copy.

TABLE 1. COMPUTER GENERATED INPUT SUMMARY (Cont.)

```
TWO VELOCITY PROFILES SPECIFIED IN X AND Z DIRECTIONS FOR --QUICK LOOKS--
DEPTH ASSUMED CONSTANT AND VELOCITIES CONSIDERED STEADY IN TIME
VELOCITY PROFILE PARAMETERS FOLLOW...
DU1 =     1.00     DU2 =     2.00     UU1 =     0.       UU2 =     0.
DW1 =     1.00     DW2 =     2.00     WW1 =     0.       WW2 =     0.


TIME PARAMETERS FOLLOW...
TIME OF DUMP =        0.00 SECONDS AFTER START OF TIDAL CYCLE
DURATION OF SIMULATION =     600.00 SECONDS AFTER DUMP
LONG TERM TIME STEP (DTL) =       15.00 SECONDS


DISCHARGE PARAMETERS...
INITIAL RADIUS OF CLOUD, RB =     .5668000
INITIAL DEPTH OF CLOUD CENTROID, DREL =     .2530
INITIAL CLOUD VELOCITIES...DU(1) =     0.          CV(1) =     0.          CW(1) =     0.

BULK PARAMETERS...
DENSITY, ROO =     1.113000
AGGREGATE VOIDS RATIO, BVOID =     .7800
LIQUID LIMIT =     116.0
AVERAGE SPECIFIC GRAVITY =     2.550

THERE ARE  4 SOLIDS,  PARAMETERS FOLLOW.......

DESCRIPTION  DENSITY(GM/CC)  CONCENTRATION(CUFT/CUFT)  FALL VELOCITY(FT/SEC)  VOIDS RATIO

 100-90         2.560                .7246E-02                 .4000E-01         .7800
 90-80          2.560                .7246E-02                 .2500E-01         .7800
 80-30          2.550                .3623E-01                 .1330E-01         .7800
  .LT. 30       2.560                .2174E-01                 .5000E-03         .7800
 FLUID          1.000                .9275                     0.

PERCENT MOISTURE CONTENT =    500.0280,     4.3105     TIMES LIQUID LIMIT
CALCULATED ENTRAINMENT COEFFICIENT =     .291954
```

TABLE 1. COMPUTER GENERATED INPUT SUMMARY (Cont.)

```
USE READ IN COEFFICIENTS
DINCR1     1.0000 DINCR2     1.0000
A    AO     .2350 BETA     0.0000 CM     1.0000 CD      .500
G.  .       .25   CDRAG    1.00   CFRIC  .010  CD3     .10 L     1.00 ALPHAC     .0010
FRICTN      .0100 F1      .1000
ALAMDA      .0050 AKYO      .0500
```

(5 of 7)

TABLE 1. COMPUTER GENERATED INPUT SUMMARY (Cont.)

```
       DEPTH GRID FOLLOWS...

 N V=  1    2    3    4    5    6    7    8    9   10   11   12   13   14   15   16   17   18   19   20   21   22   23   24
  1   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
  2   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
  3   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
  4   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
  5   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
  6   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
  7   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
  8   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
  9   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 10   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 11   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 12   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 13   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 14   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 15   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 16   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 17   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 18   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 19   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 20   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 21   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 22   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 23   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 24   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 25   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 26   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 27   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 28   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 29   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 30   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
 31   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.
```

(6 of 7)

TABLE 1. COMPUTER GENERATED INPUT SUMMARY (Cont.)

M	N=25	26	27	28	29	30	31
1	4.	4.	4.	4.	4.	4.	4.
2	4.	4.	4.	4.	4.	4.	4.
3	4.	4.	4.	4.	4.	4.	4.
4	4.	4.	4.	4.	4.	4.	4.
5	4.	4.	4.	4.	4.	4.	4.
6	4.	4.	4.	4.	4.	4.	4.
7	4.	4.	4.	4.	4.	4.	4.
8	4.	4.	4.	4.	4.	4.	4.
9	4.	4.	4.	4.	4.	4.	4.
10	4.	4.	4.	4.	4.	4.	4.
11	4.	4.	4.	4.	4.	4.	4.
12	4.	4.	4.	4.	4.	4.	4.
13	4.	4.	4.	4.	4.	4.	4.
14	4.	4.	4.	4.	4.	4.	4.
15	4.	4.	4.	4.	4.	4.	4.
16	4.	4.	4.	4.	4.	4.	4.
17	4.	4.	4.	4.	4.	4.	4.
18	4.	4.	4.	4.	4.	4.	4.
19	4.	4.	4.	4.	4.	4.	4.
20	4.	4.	4.	4.	4.	4.	4.
21	4.	4.	4.	4.	4.	4.	4.
22	4.	4.	4.	4.	4.	4.	4.
23	4.	4.	4.	4.	4.	4.	4.
24	4.	4.	4.	4.	4.	4.	4.
25	4.	4.	4.	4.	4.	4.	4.
26	4.	4.	4.	4.	4.	4.	4.
27	4.	4.	4.	4.	4.	4.	4.
28	4.	4.	4.	4.	4.	4.	4.
29	4.	4.	4.	4.	4.	4.	4.
30	4.	4.	4.	4.	4.	4.	4.
31	4.	4.	4.	4.	4.	4.	4.

(7 of 7)

TABLE 2. REPRESENTATIVE GRID GEOMETRY FOR TYPICAL EXAMPLE RUN

```
      ED ARRAY FOLLOWS...

    RANGE OF N IS    1 TO  31
3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3
3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3


    NUMBER OF GRID POINTS WITHIN ESTUARY =   841
```

TABLE 3. MATERIAL PROPERTY CHARACTERIZATION DURING CONVECTIVE DESCENT

```
NTRIAL         DT          IPLUNG NUTRL ISTEP
   1    .18829015             1     0     19
   2    .23850085E-01         1     0    143

X AND Z ARE MEASURED W/R TO BARGE POSITION

TIME     X       Y      Z     U      V      W      DEN-DIF     RADIUS  DIA   VORT.   FLUID CONC. SOLID-VOL.   CONCENTRATION
0.00    0.00    .25   0.00  0.00  0.000  0.00   .1130E+00    .67   1.33  0.0000   .9275E+00  .4499E-02   .7246E-02
                                                                                        .4499E-02   .7246E-02
                                                                                        .2250E-01   .3623E-01
                                                                                        .1350E-01   .2174E-01
 .05    0.00    .25   0.00  0.00   .155  0.00   .1125E+00    .67   1.34  0.0000   .9239E+00  .4491E-02   .7205E-02
                                                                                        .4498E-02   .7216E-02
                                                                                        .2249E-01   .3608E-01
                                                                                        .1350E-01   .2165E-01
 .10    0.00    .26   0.00  0.00   .306  0.00   .1112E+00    .67   1.34  0.0000   .9133E+00  .4491E-02   .7122E-02
                                                                                        .4498E-02   .7133E-02
                                                                                        .2249E-01   .3567E-01
                                                                                        .1350E-01   .2140E-01
 .14    0.00    .28   0.00  0.00   .449  0.00   .1091E+00    .67   1.35  0.0000   .8962E+00  .4491E-02   .6988E-02
                                                                                        .4498E-02   .6999E-02
                                                                                        .2249E-01   .3500E-01
                                                                                        .1350E-01   .2100E-01
 .19    0.00    .31   0.00  0.00   .580  0.00   .1064E+00    .68   1.36  0.0000   .8735E+00  .4491E-02   .6812E-02
                                                                                        .4498E-02   .6822E-02
                                                                                        .2249E-01   .3412E-01
                                                                                        .1350E-01   .2047E-01
 .24    0.00    .34   0.00  0.00   .697  0.00   .1031E+00    .69   1.37  0.0000   .8465E+00  .4491E-02   .6601E-02
                                                                                        .4498E-02   .6611E-02
                                                                                        .2249E-01   .3306E-01
                                                                                        .1350E-01   .1984E-01
 .29    0.00    .37   0.00  0.00   .801  0.00   .9940E-01    .70   1.39  0.0000   .8162E+00  .4491E-02   .6364E-02
                                                                                        .4498E-02   .6374E-02
```

TABLE 4. CONVECTIVE DESCENT MATERIAL PROPERTY PLOT DEFINITIONS AND NORMALIZATION VALUES FOR DISCHARGED MATERIAL CONVECTIVE DESCENT

```
PLOT OF CLOUD PATH AND RADIUS AS SEEN FROM POINT OF RELEASE

INDEPENDENT VARIABLE IS TIME (SEC) OVER RANGE     0.           3.4106

DEPENDENT VARIABLES, ALL NORMALIZED FOR PLOTTING ON UNIT AXIS

SYMBOL             Y                B                X                 Z

MAX PLOTTED     3.4732           1.4243             0.                0.
MIN PLOTTED     0.               0.                 0.                0.
REMARKS         DEPTH            RADIUS           HOR DIST(CX)      HOR DIST(CZ)



MAX,MIN,INC, OF IND.VAR.
     5.0000000          0.                  .10000000E+00

MAX,MIN,INC, OF DEP. VAR.
     1.0000000          0.                  .10000000E-01
```

TABLE 5. PLOT OF MATERIAL PROPERTIES DURING CONVECTIVE DESCENT

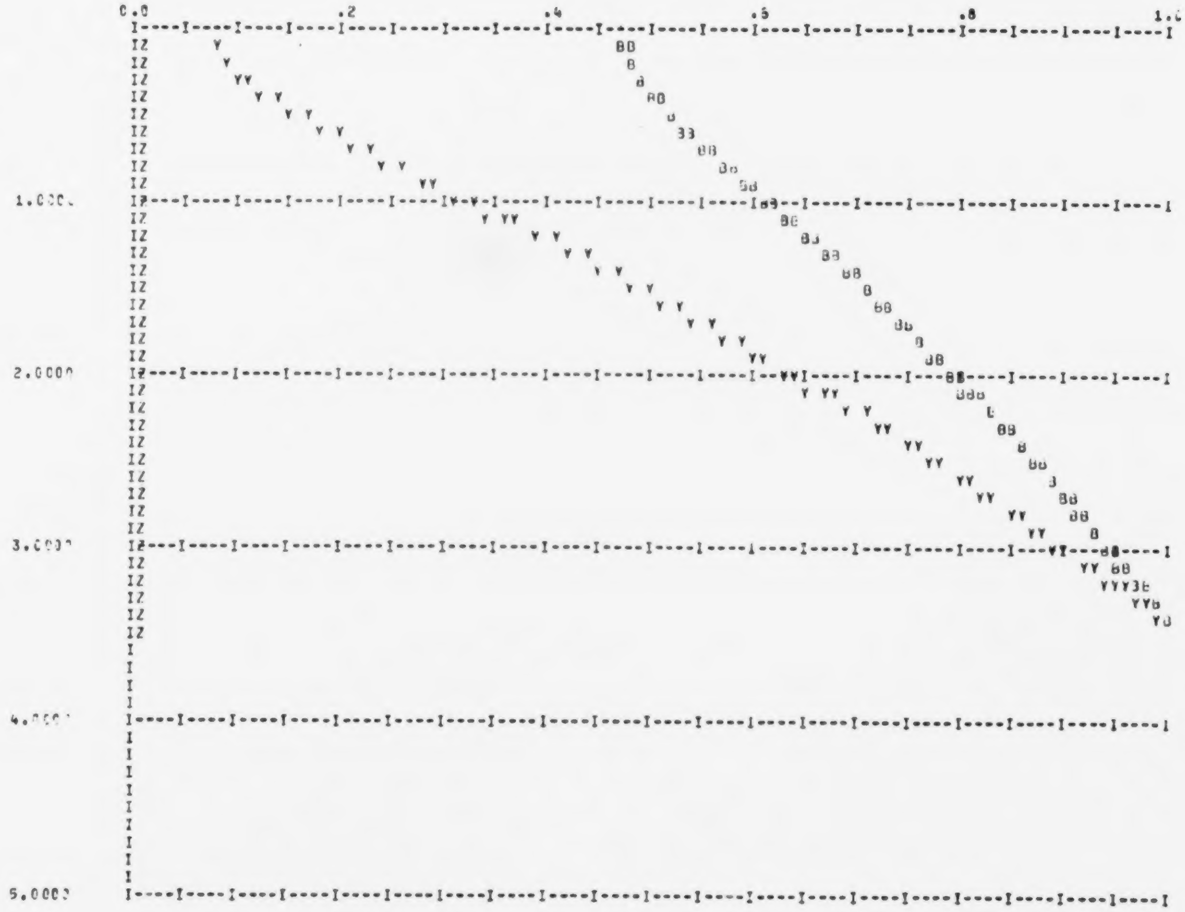


TABLE 6. MATERIAL CHARACTERIZATION DURING COLLAPSE

```
      COLLAPSE PHASE OF CLOUD

     COMPUTATIONAL INDICATORS...
 NTRIAL     DT       IPLUNG  NJTRL  ISTEP  IRED   ILEAVE
   1    .2385E-01      1       3     517    143    919

     X AND Z MEASURED FROM BARGE POSITION

 TIME         X        Y     Z            U      V     W       DEN-DIF     AA    BC          FLUID CONG.   SOLID-VOL.   CONCENTRATION
  3.39       0.00     3.47  0.           0.00  .793  0.00   .1159E-01   1.42  2.849        .9518E-01   .4491E-02   .7422E-03
                                                                                                         .4498E-02   .7434E-03
                                                                                                         .2249E-01   .3717E-02
                                                                                                         .1350E-01   .2231E-02
  3.53       0.00     3.56  0.           0.00  .527  0.00   .1157E-01   1.18  3.133        .9518E-01   .4461E-02   .7373E-03
                                                                                                         .4480E-02   .7403E-03
                                                                                                         .2244E-01   .3709E-02
                                                                                                         .1350E-01   .2231E-02
  3.67       0.00     3.62  0.           0.00  .377  0.00   .1154E-01   1.01  3.397        .9519E-01   .4426E-02   .7315E-03
                                                                                                         .4457E-02   .7367E-03
                                                                                                         .2239E-01   .3700E-02
                                                                                                         .1350E-01   .2230E-02
  3.82       0.00     3.67  0.           0.00  .283  0.00   .1150E-01    .88  3.618        .9519E-01   .4386E-02   .7249E-03
                                                                                                         .4432E-02   .7325E-03
                                                                                                         .2232E-01   .3688E-02
                                                                                                         .1349E-01   .2230E-02
  3.96       0.00     3.70  0.           0.00  .221  0.00   .1146E-01    .79  3.831        .9519E-01   .4341E-02   .7175E-03
                                                                                                         .4404E-02   .7278E-03
                                                                                                         .2224E-01   .3676E-02
                                                                                                         .1349E-01   .2230E-02
  4.10       0.00     3.73  0.           0.00  .177  0.00   .1142E-01    .71  4.028        .9519E-01   .4292E-02   .7093E-03
                                                                                                         .4372E-02   .7226E-03
                                                                                                         .2216E-01   .3662E-02
                                                                                                         .1349E-01   .2230E-02
  4.25       0.00     3.76  0.           0.00  .145  0.00   .1137E-01    .65  4.213        .9520E-01   .4238E-02   .7004E-03
                                                                                                         .4338E-02   .7170E-03
                                                                                                         .2206E-01   .3647E-02
                                                                                                         .1349E-01   .2229E-02
  4.39       0.00     3.77  0.           0.00  .121  0.00   .1132E-01    .60  4.387        .9520E-01   .4180E-02   .6909E-03
                                                                                                         .4301E-02   .7109E-03
                                                                                                         .2196E-01   .3630E-02
                                                                                                         .1349E-01   .2229E-02
  4.53       0.00     3.79  0.           0.00  .102  0.00   .1127E-01    .56  4.551        .9520E-01   .4118E-02   .6807E-03
                                                                                                         .4261E-02   .7043E-03
                                                                                                         .2185E-01   .3613E-02
                                                                                                         .1348E-01   .2229E-02
  4.67       0.00     3.80  0.           0.00  .088  0.00   .1121E-01    .52  4.705        .9521E-01   .4053E-02   .6700E-03
                                                                                                         .4219E-02   .6974E-03
                                                                                                         .2174E-01   .3594E-02
                                                                                                         .1348E-01   .2228E-02
  4.82       0.00     3.82  0.           0.00  .076  0.00   .1115E-01    .49  4.852        .9521E-01   .3985E-02   .6588E-03
                                                                                                         .4174E-02   .6901E-03
                                                                                                         .2162E-01   .3573E-02
                                                                                                         .1348E-01   .2228E-02
  4.96       0.00     3.83  0.           0.00  .066  0.00   .1109E-01    .46  4.991        .9521E-01   .3914E-02   .6470E-03
                                                                                                         .4128E-02   .6824E-03
                                                                                                         .2149E-01   .3552E-02
```

Reproduced from
best available copy.

TABLE 7. COLLAPSE PHASE MATERIAL PROPERTY PLOT DEFINITIONS AND NORMALIZATION VALUES FOR DISCHARGED MATERIAL

```
PLOT OF COLLAPSING CLOUD CHARACTERISTICS

INDEPENDENT VARIABLE IS TIME OVER RANGE     0.          12.330

DEPENDENT VARIABLE, ALL NORMALIZED FOR PLOTTING ON UNIT AXIS
SYMBOL             A                   B               C              Y
MAX PLOTTED    1.8973               7.2455          .92754         3.9177
MIN PLOTTED    0.                   0.              0.             0.
REMARKS        VERT SIZE            HOR SIZE     CONCENTRATION     DEPTH


MAX,MIN,INC, OF IND.VAR.
      15.000000        0.                     .30000000

MAX,MIN,INC, OF DEP. VAR.
      1.0000000        0.                     .10000000E-01
```

TABLE 8. PLOT OF MATERIAL PROPERTIES DURING COLLAPSE

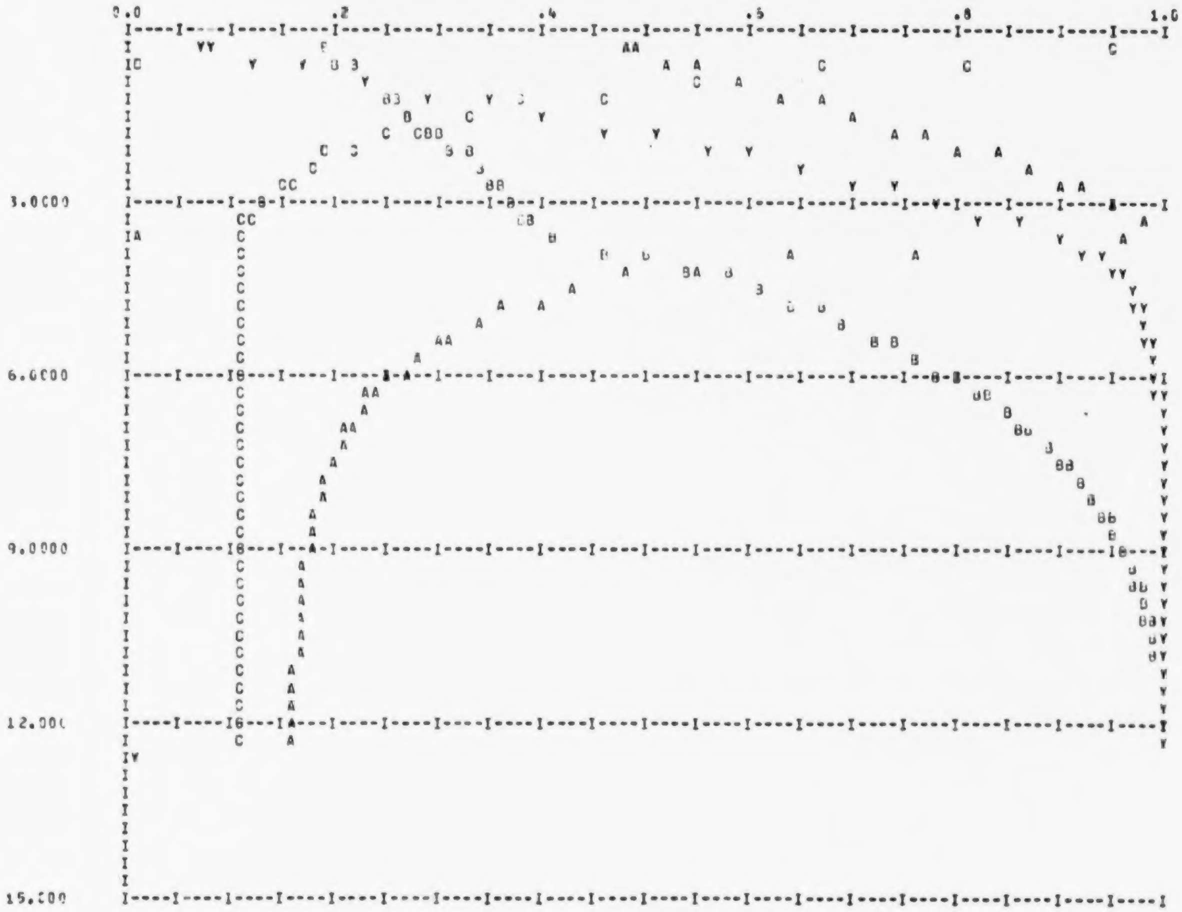


TABLE 9. MATERIAL CHARACTERIZATION DURING LONG-TERM DIFFUSION

```
        BEGIN LONG TERM SIMULATION OF FATE OF 100-92

NEW CLOUD CREATED, NTCLD =      1
  T(SEC)        TX          TZ         TSIDE        TOP        TTHK         TMASS         TEMAS          NEWT        LAST
   1.216       15.00       15.00       1.670       1.774      .4865E-01    .8044E-05    0.               52           1

NEW CLOUD CREATED, NTCLD =      2
  T(SEC)        TX          TZ         TSIDE        TOP        TTHK         TMASS         TEMAS          NEWT        LAST
   3.649       15.00       15.00       2.965       3.903      .9731E-01    .5875E-04    0.              154          52

NEW CLOUD CREATED, NTCLD =      2
  T(SEC)        TX          TZ         TSIDE        TOP        TTHK         TMASS         TEMAS          NEWT        LAST
   4.865       15.00       15.00       4.342       3.951      .4865E-01    .4710E-03    0.              205         154

NEW CLOUD CREATED, NTCLD =      2
  T(SEC)        TX          TZ         TSIDE        TOP        TTHK         TMASS         TEMAS          NEWT        LAST
   6.082       15.00       15.00       5.201       3.951      .4865E-01    .6724E-03    0.              256         205

NEW CLOUD CREATED, NTCLD =      2
  T(SEC)        TX          TZ         TSIDE        TOP        TTHK         TMASS         TEMAS          NEWT        LAST
   7.298       15.00       15.00       5.750       3.951      .4865E-01    .7105E-03    0.              307         256

NEW CLOUD CREATED, NTCLD =      2
  T(SEC)        TX          TZ         TSIDE        TOP        TTHK         TMASS         TEMAS          NEWT        LAST
   8.514       15.00       15.00       6.081       3.951      .4865E-01    .6361E-03    0.              358         307

NEW CLOUD CREATED, NTCLD =      2
  T(SEC)        TX          TZ         TSIDE        TOP        TTHK         TMASS         TEMAS          NEWT        LAST
   9.731       15.00       15.00       6.208       3.951      .4865E-01    .5150E-03    0.              409         358

NEW CLOUD CREATED, NTCLD =      2
  T(SEC)        TX          TZ         TSIDE        TOP        TTHK         TMASS         TEMAS          NEWT        LAST
   10.95       15.00       15.00       6.368       3.951      .4865E-01    .3933E-03    0.              460         409

NEW CLOUD CREATED, NTCLD =      2
  T(SEC)        TX          TZ         TSIDE        TOP        TTHK         TMASS         TEMAS          NEWT        LAST
   12.16       15.00       15.00       6.420       3.951      .4865E-01    .2906E-03    0.              511         460

NEW CLOUD CREATED, NTCLD =      2
  T(SEC)        TX          TZ         TSIDE        TOP        TTHK         TMASS         TEMAS          NEWT        LAST
   12.31       15.00       15.00       6.424       3.775      .2250        .7436E-03    0.              517         511
```

TABLE 10. MATERIAL STATUS AS A FUNCTION OF TIME DURING LONG-TERM DIFFUSION

```
OUTPUT SUPPRESSED IN LOCATIONS WITH NO MATERIAL PRESENT


SUMMARY OF 100-90     DISTRIBUTIONS AFTER      30.00 SEC.

TOTAL SUSPENDED MATERIAL (CUFT) =      .80438E-05
SUSPENDED MATERIAL IN LONG TERM GRID (CUFT) =      0.
SUSPENDED MATERIAL IN SMALL CLOUDS (CUFT) =      .80438E-05
TOTAL MATERIAL SETTLED TO BOTTOM (CUFT) =      .44912E-02

OUTPUT SUPPRESSED IN LOCATIONS WITH NO MATERIAL PRESENT


SUMMARY OF 100-90     DISTRIBUTIONS AFTER      45.00 SEC.

TOTAL SUSPENDED MATERIAL (CUFT) =      .80438E-05
SUSPENDED MATERIAL IN LONG TERM GRID (CUFT) =      .80438E-05
SUSPENDED MATERIAL IN SMALL CLOUDS (CUFT) =      0.
TOTAL MATERIAL SETTLED TO BOTTOM (CUFT) =      .44912E-02

OUTPUT SUPPRESSED IN LOCATIONS WITH NO MATERIAL PRESENT


SUMMARY OF 100-90     DISTRIBUTIONS AFTER      60.00 SEC.

TOTAL SUSPENDED MATERIAL (CUFT) =      0.
SUSPENDED MATERIAL IN LONG TERM GRID (CUFT) =      0.
SUSPENDED MATERIAL IN SMALL CLOUDS (CUFT) =      0.
TOTAL MATERIAL SETTLED TO BOTTOM (CUFT) =      .44993E-02

OUTPUT SUPPRESSED IN LOCATIONS WITH NO MATERIAL PRESENT

COMPUTATIONS FOR 100-90     TERMINATED AT      60.00  SEC. ELAPSED TIME...MATERIAL SETTLED TO BOTTOM
```

Reproduced from
best available copy.

TABLE 11. COMPONENT POSITION AS A FUNCTION OF GRID LOCATION DURING PASSIVE DIFFUSION

```
POSITION OF TOP OF  .LT. 30   CLOUD (FEET BELOW SURFACE)      150.00 SECONDS AFTER JUMP
...MULTIPLY DISPLAYED VALUES BY   1.000          (LEGEND... + = .LT. .01   . = .LT. .0001   0 = .LT. .000001)
M N=  1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30  31

 1 0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000

 2 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

 3 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

 4 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

 5 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

 6 0000   0   0   0   0   0   0   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   0   0   0   0   0   0   00000

 7 0000   0   0   0   0   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   0   0   0   0   00000

 8 0000   0   0   0   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   0   0   0   00000

 9 0000   0   0   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   0   0   00000

10 0000   0   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   0   00000

11 0000   0   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   0   00000

12 0000   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   00000

13 0000   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   00000

14 0000   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   00000

15 0000   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   00000

16 0000   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   00000

17 0000   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   00000

18 0000   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   00000

19 0000   0   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   0   00000

20 0000   0   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   0   00000

21 0000   0   0   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   0   0   00000

22 0000   0   0   0   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   0   0   0   00000

23 0000   0   0   0   0   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   0   0   0   0   00000

24 0000   0   0   0   0   0   0   0   0   0   0 3.8 3.8 3.8 3.8 3.8 3.8 3.8   0   0   0   0   0   0   0   0   0   0   0   00000

25 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

26 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

27 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

28 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

29 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

30 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000
```

TABLE 12. COMPONENT THICKNESS AS A FUNCTION OF GRID LOCATION DURING LONG-TERM DIFFUSION

```
THICKNESS OF  .LT. 30   CLOUD (FEET)      150.00 SECONDS AFTER DUMP
...MULTIPLY DISPLAYED VALUES BY   1.000         (LEGEND... + = .LT. .01    . = .LT. .0001   0 = .LT. .000001)
 M N=  1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30  31

  1 000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000)
  2 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0000)
  3 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0000)
  4 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0000)
  5 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0000)
  6 0000   0   0   0   0   0   0   0   0   0   0 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0   0   0   0   0   0   0000)
  7 0000   0   0   0   0   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0   0   0   0   0000)
  8 0000   0   0   0   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0   0   0   0000)
  9 0000   0   0   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0   0   0000)
 10 0000   0   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0   0000)
 11 0000   0   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0   0000)
 12 0000   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0000)
 13 0000   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0000)
 14 0000   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0000)
 15 0000   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0000)
 16 0000   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0000)
 17 0000   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0000)
 18 0000   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0000)
 19 0000   0   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0   0000)
 20 0000   0   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0   0000)
 21 0000   0   0   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0   0   0000)
 22 0000   0   0   0   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0   0   0   0000)
 23 0000   0   0   0   0   0   0   0   0 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0   0   0   0   0000)
 24 0000   0   0   0   0   0   0   0   0   0   0 .15 .15 .15 .15 .15 .15 .15   0   0   0   0   0   0   0   0   0   0   0   0000)
 25 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0000)
 26 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0000)
 27 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0000)
 28 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0000)
 29 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0000)
 30 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0000)
 31 000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000)
```

TABLE 13. COMPONENT BOTTOM ACCUMULATION AS A FUNCTION OF GRID LOCATION DURING LONG TERM DIFFUSION

```
BOTTOM ACCUMULATION OF  .LT. 3C   (CUFT/GRID SQUARE)      150.00 SECONDS AFTER DUMP
...MULTIPLY DISPLAYED VALUES BY   .1000E-04      (LEGEND... + = .LT. .01   . = .LT. .0001   0 = .LT. .000001)
M N=  1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30  31

 1 0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000

 2 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

 3 0000   0   0   0   0   0   0       0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

 4 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

 5 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

 6 0000   0   0   0   0   0   0   0   0   0   0   .   .   .   .   .   .   .   0   0   0   0   0   0   0   0   0   0   0   00000

 7 0000   0   0   0   0   0   0   0   0   .   .   +   +   +   +   +   +   +   .   .   0   0   0   0   0   0   0   0   0   00000

 8 0000   0   0   0   0   0   0   0   .   +   +   +   +   +   +   +   +   +   +   +   .   .   0   0   0   0   0   0   0   00000

 9 0000   0   0   0   0   0   0   .   +   + .01 .03 .04 .04 .04 .04 .04 .03 .01   +   +   .   0   0   0   0   0   0   0   00000

10 0000   0   0   0   0   0   .   +   + .01 .08 .24 .31 .33 .33 .33 .31 .24 .08 .01   +   +   .   0   0   0   0   0   0   00000

11 0000   0   0   0   0   0   .   + .01 .08 .40 1.0 1.3 1.4 1.4 1.4 1.3 1.0 .40 .08 .01   +   .   0   0   0   0   0   0   00000

12 0000   0   0   0   0   .   +   + .03 .24 1.0 3.3 4.1 4.3 4.4 4.3 4.1 3.3 1.0 .24 .03   +   +   .   0   0   0   0   0   00000

13 0000   0   0   0   0   .   +   + .04 .31 1.3 4.1 5.3 5.6 5.6 5.5 5.3 4.1 1.3 .31 .04   +   +   .   0   0   0   0   0   00000

14 0000   0   0   0   0   .   +   + .04 .33 1.4 4.3 5.6 5.8 5.9 5.8 5.6 4.3 1.4 .33 .04   +   +   .   0   0   0   0   0   00000

15 0000   0   0   0   0   .   +   + .04 .33 1.4 4.4 5.6 5.9 5.9 5.9 5.6 4.4 1.4 .33 .04   +   +   .   0   0   0   0   0   00000

16 0000   0   0   0   0   .   +   + .04 .33 1.4 4.3 5.6 5.8 5.9 5.8 5.6 4.3 1.4 .33 .04   +   +   .   0   0   0   0   0   00000

17 0000   0   0   0   0   .   +   + .04 .31 1.3 4.1 5.3 5.6 5.6 5.5 5.3 4.1 1.3 .31 .04   +   +   .   0   0   0   0   0   00000

18 0000   0   0   0   0   .   +   + .03 .24 1.0 3.3 4.1 4.3 4.4 4.3 4.1 3.3 1.0 .24 .03   +   +   .   0   0   0   0   0   00000

19 0000   0   0   0   0   0   .   + .01 .08 .40 1.0 1.3 1.4 1.4 1.4 1.3 1.0 .40 .08 .01   +   .   0   0   0   0   0   0   00000

20 0000   0   0   0   0   0   .   +   + .01 .08 .24 .31 .33 .33 .33 .31 .24 .08 .01   +   +   .   0   0   0   0   0   0   00000

21 0000   0   0   0   0   0   0   .   +   + .01 .03 .04 .04 .04 .04 .04 .03 .01   +   +   .   0   0   0   0   0   0   0   00000

22 0000   0   0   0   0   0   0   0   .   +   +   +   +   +   +   +   +   +   +   +   .   0   0   0   0   0   0   0   0   00000

23 0000   0   0   0   0   0   0   0   0   .   .   +   +   +   +   +   +   +   .   .   0   0   0   0   0   0   0   0   0   00000

24 0000   0   0   0   0   0   0   0   0   0   0   .   .   .   .   .   .   .   0   0   0   0   0   0   0   0   0   0   0   00000

25 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

26 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

27 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

28 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

29 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000

30 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   00000
```

Reproduced from
best available copy.

TABLE 14. COMPONENT CONCENTRATION AS A FUNCTION OF GRID LOCATION DURING PASSIVE DIFFUSION

```
CONCENTRATIONS OF  .LT. 30   (VOLUME RATIO) IN THE CLOUD     150.00 SECONDS AFTER DUMP
...MULTIPLY DISPLAYED VALUES BY   .1000E-02     (LEGEND... + = .LT. .01    . = .LT. .0001    0 = .LT. .000001)
 M N=   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30  31

  1 000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
  2 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 0000
  3 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 0000
  4 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 0000
  5 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 0000
  6 0000   0   0   0   0   0   0   0   0   0   0   .   .   .   .   .   .   .   0   0   0   0   0   0   0   0   0   0   0 0000
  7 0000   0   0   0   0   0   0   0   0   .   .   +   +   +   +   +   +   +   .   .   0   0   0   0   0   0   0   0   0 0000
  8 0000   0   0   0   0   0   0   0   .   +   +   +   +   +   +   +   +   +   +   +   .   0   0   0   0   0   0   0   0 0000
  9 0000   0   0   0   0   0   0   .   +   +   + .01 .02 .02 .02 .02 .02 .01   +   +   +   .   0   0   0   0   0   0   0 0000
 10 0000   0   0   0   0   0   .   +   +   + .03 .08 .11 .12 .12 .12 .11 .08 .03   +   +   +   .   0   0   0   0   0   0 0000
 11 0000   0   0   0   0   0   .   +   + .03 .13 .31 .41 .44 .44 .44 .41 .31 .13 .03   +   +   .   0   0   0   0   0   0 0000
 12 0000   0   0   0   0   .   +   + .01 .08 .31 .67 .89 .96 .98 .95 .89 .67 .31 .08 .01   +   +   .   0   0   0   0   0 0000
 13 0000   0   0   0   0   .   +   + .02 .11 .41 .89 1.1 1.2 1.3 1.2 1.1 .89 .41 .11 .02   +   +   .   0   0   0   0   0 0000
 14 0000   0   0   0   0   .   +   + .02 .12 .44 .96 1.2 1.3 1.4 1.3 1.2 .96 .44 .12 .02   +   +   .   0   0   0   0   0 0000
 15 0000   0   0   0   0   .   +   + .02 .12 .44 .98 1.3 1.4 1.4 1.4 1.3 .99 .44 .12 .02   +   +   .   0   0   0   0   0 0000
 16 0000   0   0   0   0   .   +   + .02 .12 .44 .96 1.2 1.3 1.4 1.3 1.2 .96 .44 .12 .02   +   +   .   0   0   0   0   0 0000
 17 0000   0   0   0   0   .   +   + .02 .11 .41 .89 1.1 1.2 1.3 1.2 1.1 .89 .41 .11 .02   +   +   .   0   0   0   0   0 0000
 18 0000   0   0   0   0   .   +   + .01 .08 .31 .67 .89 .96 .98 .95 .89 .67 .31 .08 .01   +   +   .   0   0   0   0   0 0000
 19 0000   0   0   0   0   0   .   +   + .03 .13 .31 .41 .44 .44 .44 .41 .31 .13 .03   +   +   .   0   0   0   0   0   0 0000
 20 0000   0   0   0   0   0   .   +   +   + .03 .08 .11 .12 .12 .12 .11 .08 .03   +   +   +   .   0   0   0   0   0   0 0000
 21 0000   0   0   0   0   0   0   .   +   +   + .01 .02 .02 .02 .02 .02 .01   +   +   +   .   0   0   0   0   0   0   0 0000
 22 0000   0   0   0   0   0   0   0   .   +   +   +   +   +   +   +   +   +   +   +   .   0   0   0   0   0   0   0   0 0000
 23 0000   0   0   0   0   0   0   0   0   .   .   +   +   +   +   +   +   +   .   .   0   0   0   0   0   0   0   0   0 0000
 24 0000   0   0   0   0   0   0   0   0   0   0   .   .   .   .   .   .   .   0   0   0   0   0   0   0   0   0   0   0 0000
 25 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 0000
 26 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 0000
 27 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 0000
 28 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 0000
 29 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 0000
 30 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 0000
 31 000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000
```

TABLE 15. TOTAL MATERIAL ACCUMULATED ON BOTTOM

```
TOTAL ACCUMULATED SOLID VOLUME ON BOTTOM (CUFT/GRID SQR),        0.00 SECONDS AFTER DUMP
...MULTIPLY DISPLAYED VALUES BY   .1000E-03     (LEGEND... + = .LT. .01   . = .LT. .0001   0 = .LT. .000001)
 M N=  1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30  31
  1 00000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000)
  2 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  0000)
  3 0000   0   0   0   0   0   0   0   0   0   0   .   .   .   .   .   .   .   0   0   0   0   0   0   0   0   0   0   0  0000)
  4 0000   0   0   0   0   0   0   0   0   .   .   .   .   .   .   .   .   .   .   .   0   0   0   0   0   0   0   0   0  0000)
  5 0000   0   0   0   0   0   0   .   .   .   +   +   +   +   +   +   +   +   +   .   .   .   0   0   0   0   0   0   0  0000)
  6 0000   0   0   0   0   0   .   .   +   +   +   +   +   +   +   +   +   +   +   +   +   .   .   0   0   0   0   0   0  0000)
  7 0000   0   0   0   0   .   .   +   +   +   +   + .01 .01 .01 .01 .01   +   +   +   +   +   .   .   0   0   0   0   0  0000)
  8 0000   0   0   0   .   .   +   +   +   + .01 .02 .03 .04 .04 .04 .03 .02 .01   +   +   +   +   .   .   0   0   0   0  0000)
  9 0000   0   0   0   .   +   +   + .01 .02 .05 .09 .12 .13 .14 .13 .12 .09 .05 .02 .01   +   +   +   .   0   0   0   0  0000)
 10 0000   0   0   .   .   +   +   + .02 .07 .15 .26 .34 .38 .39 .38 .34 .26 .15 .07 .02   +   +   +   .   .   0   0   0  0000)
 11 0000   0   0   .   +   +   + .01 .05 .15 .34 .79 .98 1.0 1.0 1.0 .98 .79 .34 .15 .05 .01   +   +   +   .   .   0   0  0000)
 12 0000   0   .   .   +   +   + .02 .09 .26 .79 6.8 7.4 7.5 7.6 7.5 7.4 6.8 .79 .25 .09 .02   +   +   +   .   .   0   0  0000)
 13 0000   0   .   .   +   + .01 .03 .12 .34 .98 7.4 8.7 8.9 9.0 8.9 8.7 7.4 .98 .34 .12 .03 .01   +   +   .   .   0   0  0000)
 14 0000   0   .   .   +   + .01 .04 .13 .38 1.0 7.5 8.9 9.2 9.2 9.2 8.9 7.5 1.0 .38 .13 .04 .01   +   +   .   .   0   0  0000)
 15 0000   0   .   .   +   + .01 .04 .14 .39 1.0 7.6 9.0 9.2 9.3 9.2 9.0 7.6 1.0 .39 .14 .04 .01   +   +   .   .   0   0  0000)
 16 0000   0   .   .   +   + .01 .04 .13 .38 1.0 7.5 8.9 9.2 9.2 9.2 8.9 7.5 1.0 .38 .13 .04 .01   +   +   .   .   0   0  0000)
 17 0000   0   .   .   +   + .01 .03 .12 .34 .98 7.4 8.7 8.9 9.0 8.9 8.7 7.4 .98 .34 .12 .03 .01   +   +   .   .   0   0  0000)
 18 0000   0   .   .   +   +   + .02 .09 .26 .79 6.8 7.4 7.5 7.6 7.5 7.4 6.8 .79 .26 .09 .02   +   +   +   .   .   0   0  0000)
 19 0000   0   0   .   +   +   + .01 .05 .15 .34 .79 .98 1.0 1.0 1.0 .98 .79 .34 .15 .05 .01   +   +   +   .   .   0   0  0000)
 20 0000   0   0   .   .   +   +   + .02 .07 .15 .26 .34 .38 .39 .38 .34 .26 .15 .07 .02   +   +   +   .   .   0   0   0  0000)
 21 0000   0   0   0   .   +   +   + .01 .02 .05 .09 .12 .13 .14 .13 .12 .09 .05 .02 .01   +   +   +   .   0   0   0   0  0000)
 22 0000   0   0   0   .   .   +   +   +   + .01 .02 .03 .04 .04 .04 .03 .02 .01   +   +   +   +   .   .   0   0   0   0  0000)
 23 0000   0   0   0   0   .   .   +   +   +   +   + .01 .01 .01 .01 .01   +   +   +   +   +   .   .   0   0   0   0   0  0000)
 24 0000   0   0   0   0   0   .   .   +   +   +   +   +   +   +   +   +   +   +   +   +   .   .   0   0   0   0   0   0  0000)
 25 0000   0   0   0   0   0   0   .   .   .   +   +   +   +   +   +   +   +   +   .   .   .   0   0   0   0   0   0   0  0000)
 26 0000   0   0   0   0   0   0   0   0   .   .   .   .   .   .   .   .   .   .   .   0   0   0   0   0   0   0   0   0  0000)
 27 0000   0   0   0   0   0   0   0   0   0   0   .   .   .   .   .   .   .   0   0   0   0   0   0   0   0   0   0   0  0000)
 28 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  0000)
 29 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  0000)
 30 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  0000)
 31 00000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000)
```

Reproduced from
best available copy.

TABLE 16. TOTAL THICKNESS OF ACCUMULATED BOTTOM MATERIAL

```
TOTAL THICKNESS (FT) OF NEW MATERIAL ON BOTTOM,      0.00 SECONDS AFTER DUMP
...MULTIPLY DISPLAYED VALUES BY   .100E-02     (LEGEND... + = .LT. .01   . = .LT. .0001   0 = .LT. .000001)
M N=   1   2   3   4   5   6   7   8   9  10  11  12  13  14  15  16  17  18  19  20  21  22  23  24  25  26  27  28  29  30  31

  1 0000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000000

  2 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 00000

  3 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 00000

  4 0000   0   0   0   0   0   0   0   0   0   .   .   .   .   .   .   .   .   .   0   0   0   0   0   0   0   0   0   0 00000

  5 0000   0   0   0   0   0   0   0   .   .   .   .   .   .   +   .   .   .   .   .   .   0   0   0   0   0   0   0   0 00000

  6 0000   0   0   0   0   0   .   .   .   .   +   +   +   +   +   +   +   +   +   .   .   .   .   0   0   0   0   0   0 00000

  7 0000   0   0   0   0   .   .   .   +   +   +   +   +   +   +   +   +   +   +   +   +   .   .   .   0   0   0   0   0 00000

  8 0000   0   0   0   0   .   .   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   .   .   0   0   0   0   0 00000

  9 0000   0   0   0   .   .   +   +   +   + .01 .01 .02 .02 .02 .02 .02 .01 .01   +   +   +   +   .   .   0   0   0   0 00000

 10 0000   0   0   0   .   .   +   +   + .01 .02 .04 .06 .06 .07 .06 .06 .04 .02 .01   +   +   +   .   .   0   0   0   0 00000

 11 0000   0   0   .   .   +   +   + .01 .02 .06 .14 .17 .19 .19 .19 .17 .14 .06 .02 .01   +   +   +   .   .   0   0   0 00000

 12 0000   0   0   .   .   +   +   + .01 .04 .14 1.2 1.3 1.3 1.3 1.3 1.3 1.2 .14 .04 .01   +   +   +   .   .   0   0   0 00000

 13 0000   0   0   .   .   +   +   + .02 .06 .17 1.3 1.5 1.5 1.6 1.6 1.5 1.3 .17 .06 .02   +   +   +   .   .   0   0   0 00000

 14 0000   0   0   .   .   +   +   + .02 .06 .19 1.3 1.5 1.6 1.6 1.6 1.6 1.3 .19 .06 .02   +   +   +   .   .   0   0   0 00000

 15 0000   0   0   .   +   +   +   + .02 .07 .19 1.3 1.6 1.6 1.6 1.6 1.6 1.3 .19 .07 .02   +   +   +   +   .   0   0   0 00000

 16 0000   0   0   .   .   +   +   + .02 .06 .19 1.3 1.6 1.6 1.6 1.6 1.5 1.3 .19 .06 .02   +   +   +   .   .   0   0   0 00000

 17 0000   0   0   .   .   +   +   + .02 .06 .17 1.3 1.5 1.6 1.6 1.5 1.5 1.3 .17 .06 .02   +   +   +   .   .   0   0   0 00000

 18 0000   0   0   .   .   +   +   + .01 .04 .14 1.2 1.3 1.3 1.3 1.3 1.3 1.2 .14 .04 .01   +   +   +   .   .   0   0   0 00000

 19 0000   0   0   .   .   +   +   + .01 .02 .06 .14 .17 .19 .19 .19 .17 .14 .06 .02 .01   +   +   +   .   .   0   0   0 00000

 20 0000   0   0   0   .   .   +   +   + .01 .02 .04 .06 .06 .07 .06 .06 .04 .02 .01   +   +   +   .   .   0   0   0   0  0000

 21 0000   0   0   0   .   .   +   +   +   + .01 .01 .02 .02 .02 .02 .02 .01 .01   +   +   +   +   .   .   0   0   0   0 00000

 22 0000   0   0   0   0   .   .   +   +   +   +   +   +   +   +   +   +   +   +   +   +   +   .   .   0   0   0   0   0 00000

 23 0000   0   0   0   0   .   .   .   +   +   +   +   +   +   +   +   +   +   +   +   +   .   .   .   0   0   0   0   0 00000

 24 0000   0   0   0   0   0   .   .   .   .   +   +   +   +   +   +   +   +   +   .   .   .   .   0   0   0   0   0   0 00000

 25 0000   0   0   0   0   0   0   0   .   .   .   .   .   .   +   .   .   .   .   .   .   0   0   0   0   0   0   0   0 00000

 26 0000   0   0   0   0   0   0   0   0   0   .   .   .   .   .   .   .   .   .   0   0   0   0   0   0   0   0   0   0 00000

 27 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 00000

 28 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 00000

 29 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 00000

 30 0000   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 00000
```

Reproduced from
best available copy.

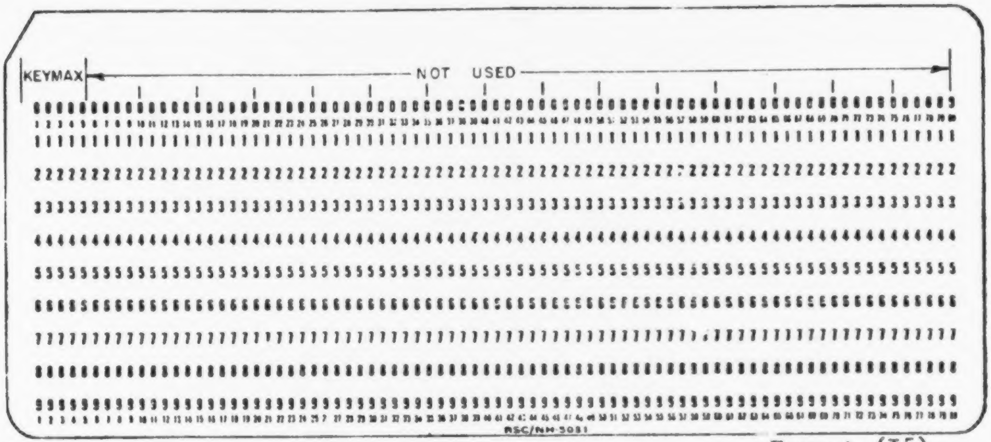
tively. In this case the grid was 31 by 31 with 1-foot spacing, a typical tank-scale run where the size of the tank was increased to eliminate wall effects. A real dump might involve thousands of cubic yards of discharged material and cover several hectares. By running the model at tank scale to achieve tank-scale predictions, problems in scale-up of tank discharges were avoided. Appendix A contains a complete listing of the program.

B. Simplified Input/Output Format

This section presents the simplified input/output format option of the long program version. It was developed to simplify the use of the program and to eliminate superfluous output necessary for the person only interested in the program results.

The type of input format is again specified by the value of KEYMAX. Thus, for the simplified input/output version the value of KEYMAX should be set to 0 (Figure 31). Figures 32 through 46 represent the input cards and parameters required to execute a run of this version specified in the input cards as well as descriptions of how to calculate these parameters. As can be seen, many of the option parameters have been eliminated. This program version requires only 3 material components and assumes a value of 20 for the number of transition levels allowed between long and short term models. Equation coefficients are fixed and the program will run to the time specified. No option is allowed for varying the print output. The user will obtain plots describing material characteristics for the convective descent and collapse phases as a function of time. Material characteristics for the total cloud as a function of time and grid location are presented for the long-term passive diffusion stage. These characteristics include cloud locations, size, and concentration as well as the quantity and height of the material that settled to the bottom. For this version it was assumed that only the total material properties are of importance.

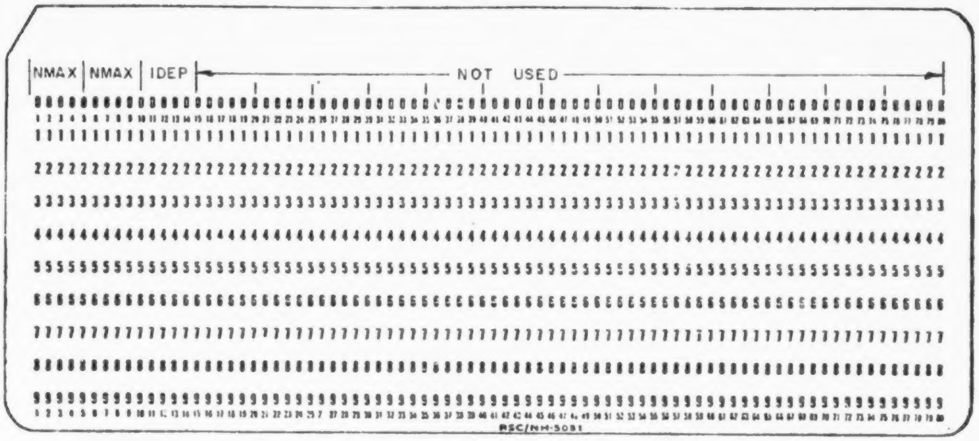
It should be noted that the grid can still be defined by a 31 × 31 matrix and the bottom is not assumed flat unless IDEP is set equal to 1. By setting KEYMAX to 0 the capabilities of the program are not reduced, only the input/output formats are simplified.



Format (I5)

VARIABLE	DEFINITION
Keymax	Flag which specifies desired input/output format. KEYMAX = 0 specifies simplified format option and is used when using the simplified format of the long program version.

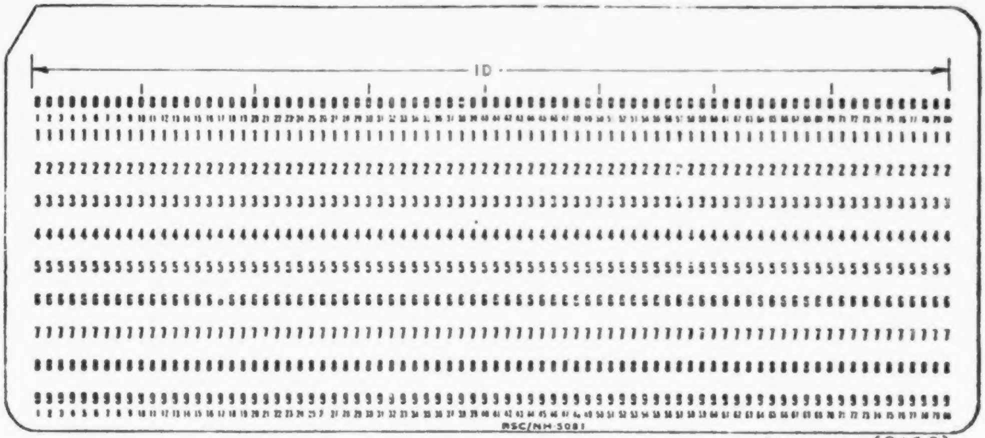
Figure 31. Input Card Number One, Simplified Input/Output



Format (16I5)

VARIABLE	DEFINITION
NMAX	Array size in Z direction ($NMAX \leq 31$)
NMAX	Array size in X direction ($MMAX \leq 31$)
IDEP	If IDEP equals 1 then the program will assume a constant depth estuary and consequently require only one value of estuary depth, H.

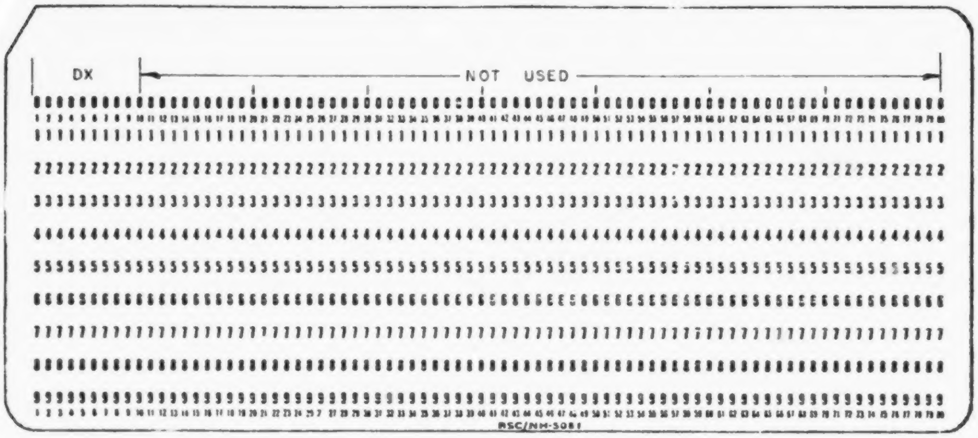
Figure 32. Input Card Number Two, Simplified Input/Output



Format (8A10)

VARIABLE	DEFINITION
ID	All 80 columns can be used to describe the run being made. Symbols can be either numeric or alphabetical.

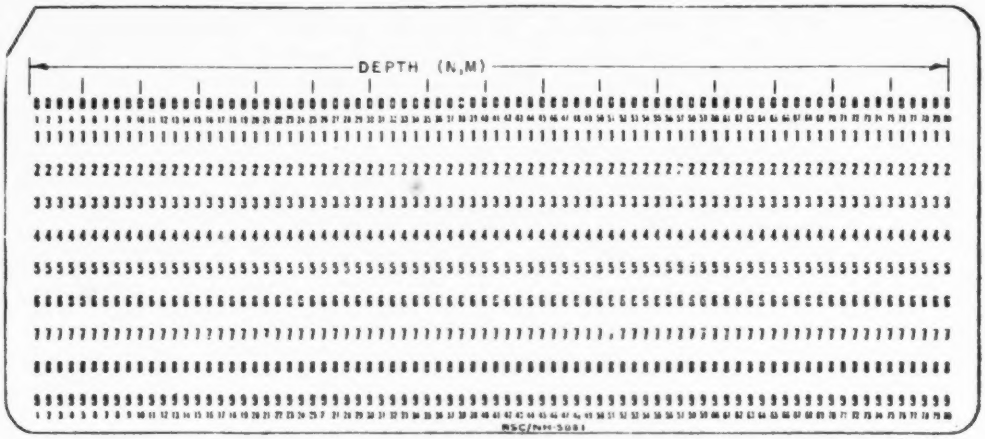
Figure 33. Input Card Number Three, Simplified Input/Output



Format (8E10.0)

VARIABLE	DEFINITION
DX	Grid space size (see Figure 1). The grid spacing is assumed symmetrical in the X and Z directions and as a result the values of DY is specified by specifying DX. DX is defined in feet.

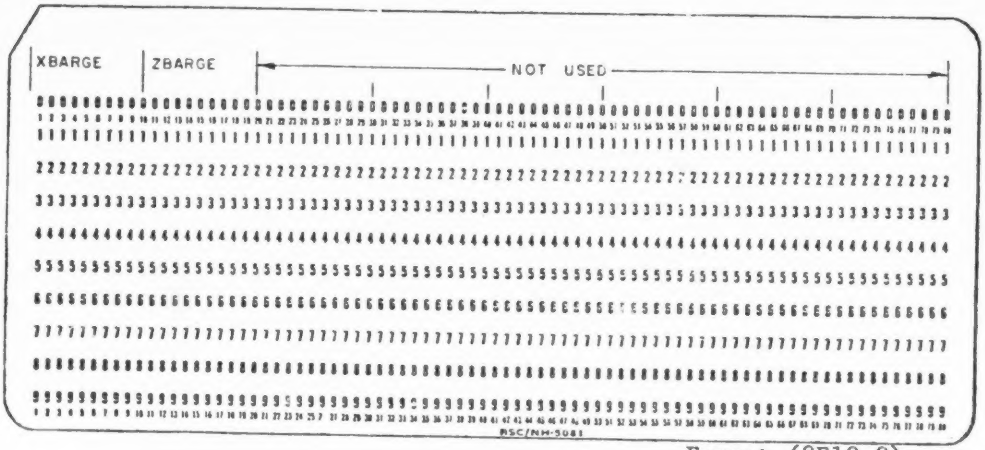
Figure 34. Input Card Number Four, Simplified Input/Output.



Format (16F5.0)

VARIABLE	DEFINITION
DEPTH(N,M)	Depths of grid point N,M. The grid is defined first by row and then by column. If a grid greater than 16 by 16 is specified the Z grid points in the first row (x grid point 1) from 17 to 31 will be defined on a second input card. After all the Z grid points in the first row have been defined the Z grids points in the second row will be defined in the next input card(s). This will continue until the entire array is filled. Thus for a 31 x 31 array 62 input cards will be necessary (two to describe each row in the grid). Depth is defined in feet. If IDEP equals one the program will assume a constant depth estuary and only H = DEPTH(1,1) need be specified in columns 1 through 5.

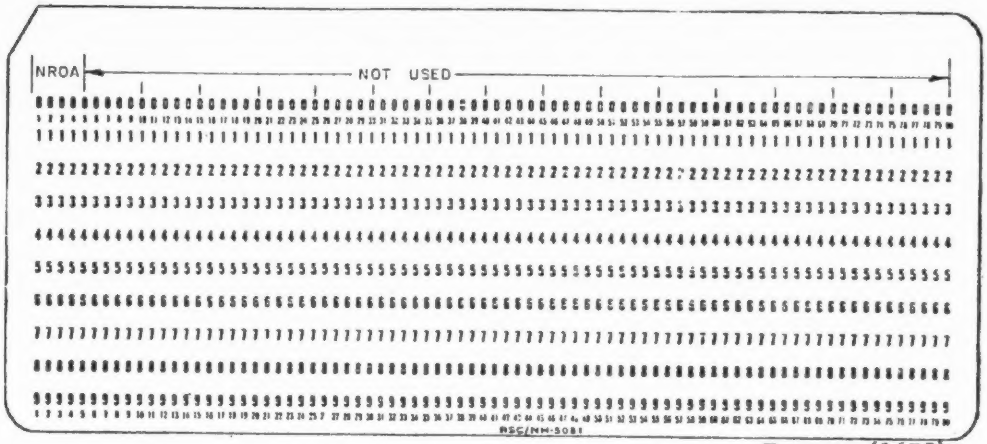
Figure 35. Input Card Number Five, Simplified Input/Output.



Format (8E10.0)

VARIABLE	DEFINITION
XBARGE	X-coordinate of barge at time of discharge. This coordinate is measured from the grid point 1,1 (see Figure 1) and does not have to be at a grid point itself. XBARGE is defined in feet.
ZBARGE	Z-coordinate is measured from the grid point 1,1 (see Figure 1), and does not have to be at a grid point itself. ZBARGE is defined in feet.

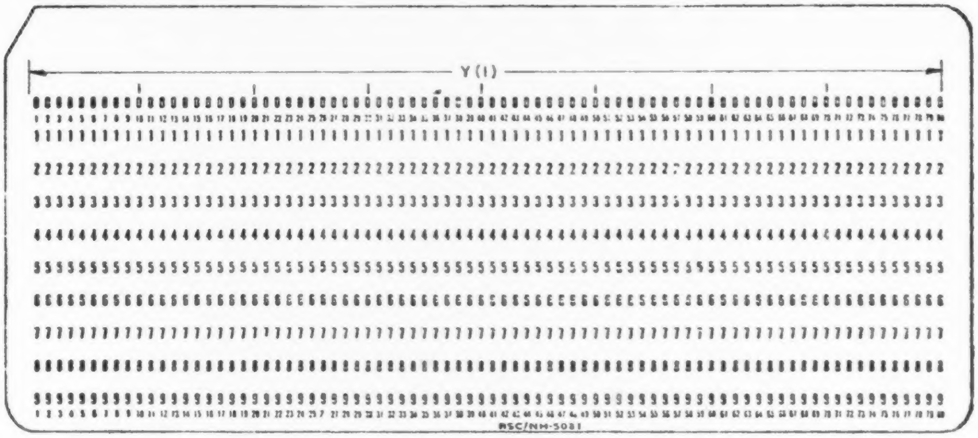
Figure 36. Input Card Number Six, Simplified Input/output



Format (16I5)

VARIABLE	DEFINITION
NROA	Number of depths at which ambient density is defined (NROA≤10).

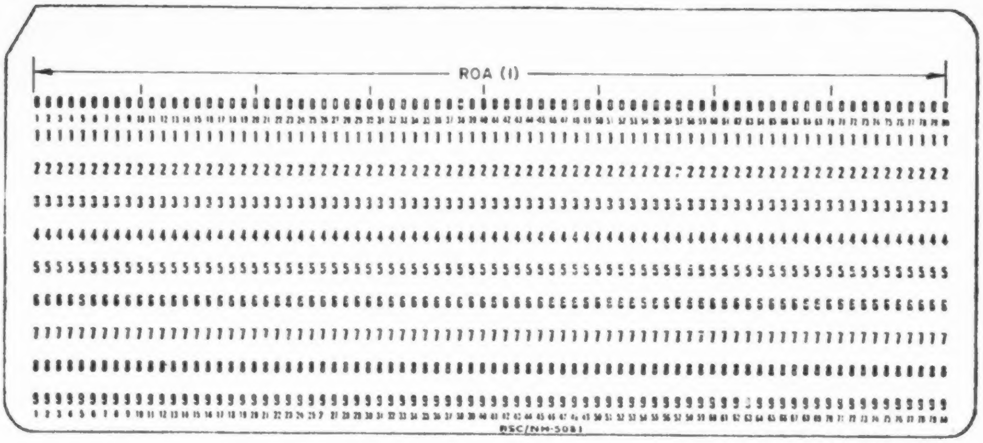
Figure 37. Input Card Number Seven, Simplified Input/Output



Format (8E10.0)

VARIABLE	DEFINITION
Y(I)	Depths at which density is defined. The quantity of Y(I) must be equal to NROA. The greatest depth in the drop zone must be equal to Y(NROA). Since (I) can vary up to 10 a second input card will be necessary to define Y(9) and Y(10). Y(I) is defined in feet.

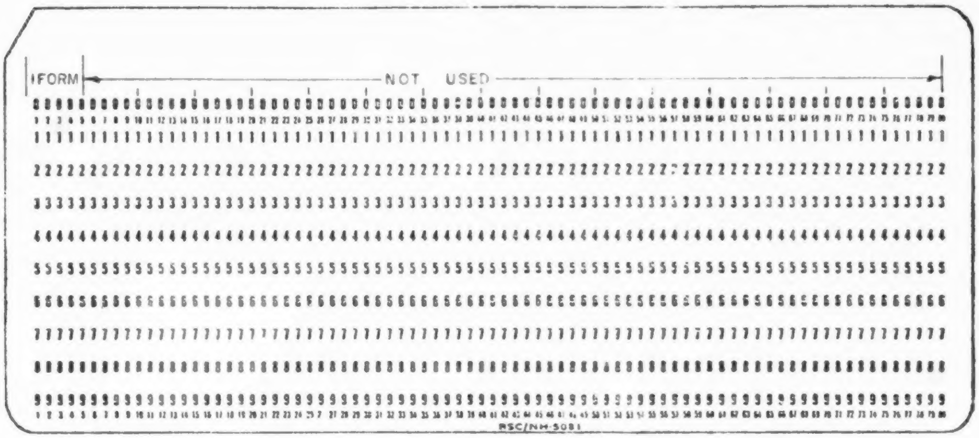
Figure 38. Input Card Number Eight, Simplified Input/Output



Format (8E10.0)

VARIABLE	DEFINITION
ROA(I)	Density in ambient water at corresponding depths, Y(I). Since (I) can vary up to 10 a second input card will be needed to define ROA(9) and ROA(10). ROA(I) is defined in grams/cc.

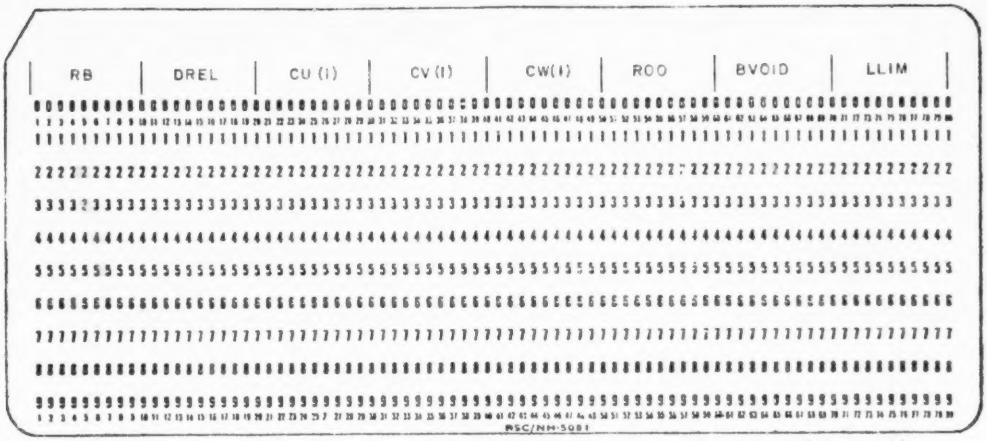
Figure 39. Input Card Number Nine, Simplified Input/Output



Format (16I5)

VARIABLE	DEFINITION
IFORM	If IFORM equals one, vertically averaged ambient velocities which are variable in the horizontal and in time, are read from logical unit 7 (see Appendix C). If IFORM equals 2, the program will generate a logarithmic velocity profile whose average value is that value of velocity read in at each time step. The format is the same as for IFORM = 1, and velocity may vary in the horizontal plane and in time. If IFORM equals three the ambient velocity will be two layers and assumed variable in the horizontal and vertical directions as well as in time (see Appendix C). If IFORM equals four the two layer ambient velocity profile is assumed constant in both the horizontal plane and time. (see Appendix C).

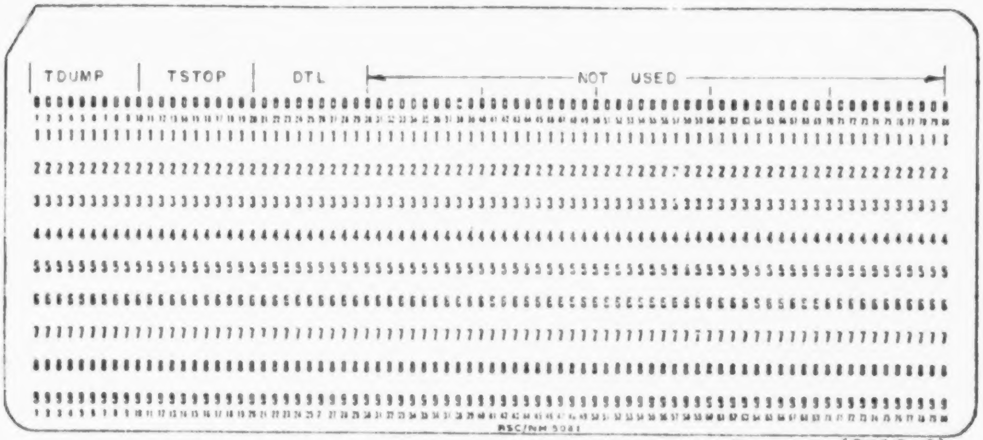
Figure 40. Input Card Number Ten, Simplified Input/Output



Format (8E10.0)

VARIABLE	DEFINITION
RB	Radius of hemispherical dredge material cloud at discharge (see page 10). RB is defined in feet.
DREL	Depth of cloud centroid at discharge. DREL is defined in feet.
CU(1) CV(1) CW(1)	Initial velocity of cloud centroid at release in the x, y, and z directions respectively (see page 10). CU(1), CV(1), and CW(1) are defined in feet/second.
ROO	Bulk density of aggregate dredge material. ROO is defined in gm/cc.
BVOID	Voids ratio of aggregate dredge material.
LLIM	Liquid limit of aggregate dredge material.

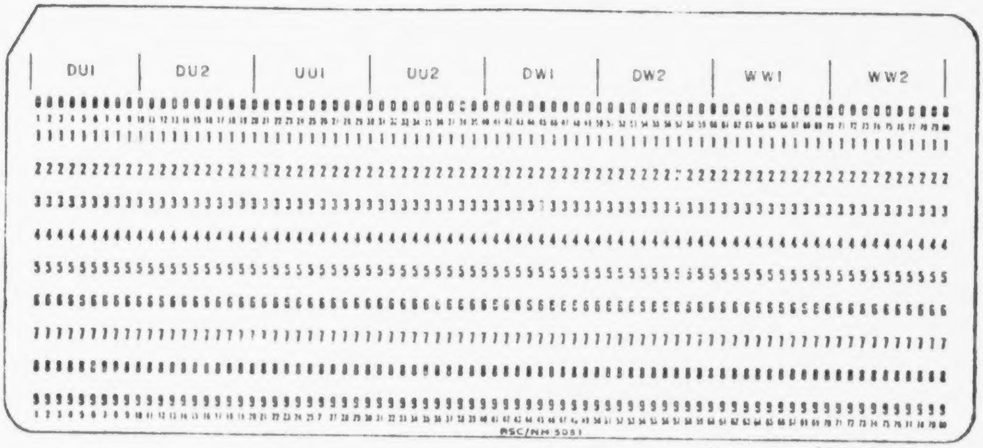
Figure 43. Input Card Number Thirteen, Simplified Input/Output



Format (8E10.0)

VARIABLE	DEFINITION
TDUMP	Time of dump relative to the start of tidal cycle (to the nearest DTL seconds).
TSTOP	Duration of simulation (to the nearest DTL seconds).
DTL	Long term integration time increment as well as the time increment between velocity data points. DTL is expressed in seconds.

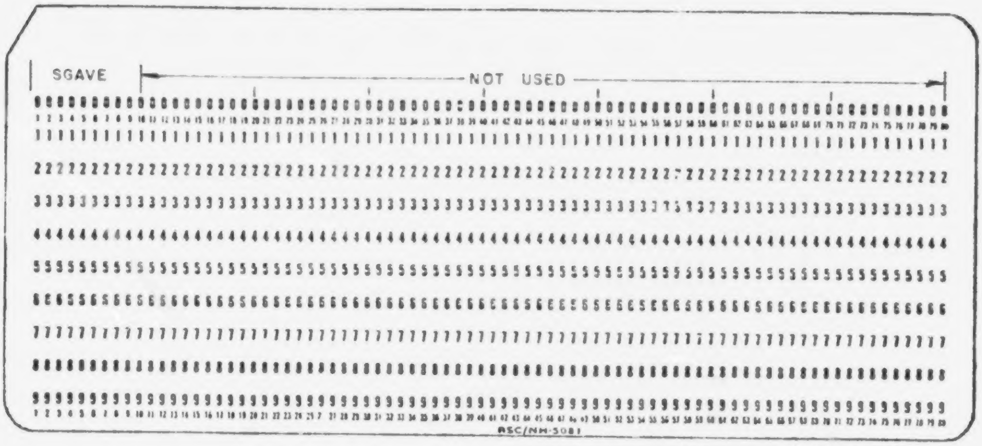
Figure 42. Input Card Number Twelve, Simplified Input/Output



Format (8E10.0)

VARIABLE	DEFINITION
DU1	Depth at which upper x velocity is specified (see Figure 2). DU1 is defined in feet.
DU2	Depth at which lower x velocity is specified (see Figure 2) DU2 is defined in feet.
UU1	Upper x velocity. UU1 is defined in ft/sec.
UU2	Lower x velocity. UU2 is defined in ft/sec.
DW1	Depth at which upper z velocity is specified (see Figure 2). DW1 is defined in feet.
DW2	Depth at which lower z velocity is specified (see Figure 2). DW2 is defined in feet.
WW1	Upper z velocity. WW1 is defined in ft/sec.
WW2	Lower z velocity. WW2 is defined in ft/sec.

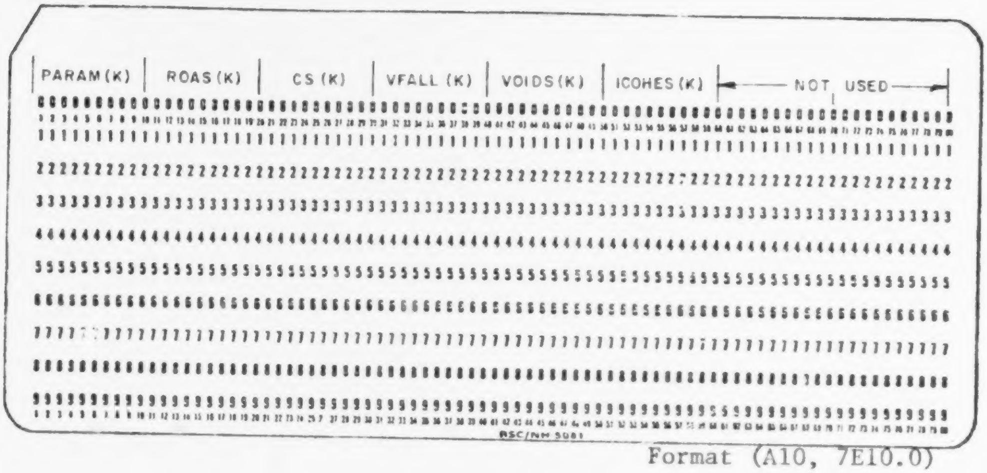
Figure 41. Input Card Number Eleven, Simplified Input/Output


SGAVE
NOT USED
ASC/NM-5081

Format (8E10.0)

VARIABLE	DEFINITION
SGAVE	Average Specific Gravity for the aggregate dredged material (see Appendix D).

Figure 44. Input Card Number Fourteen, Simplified Input/Output

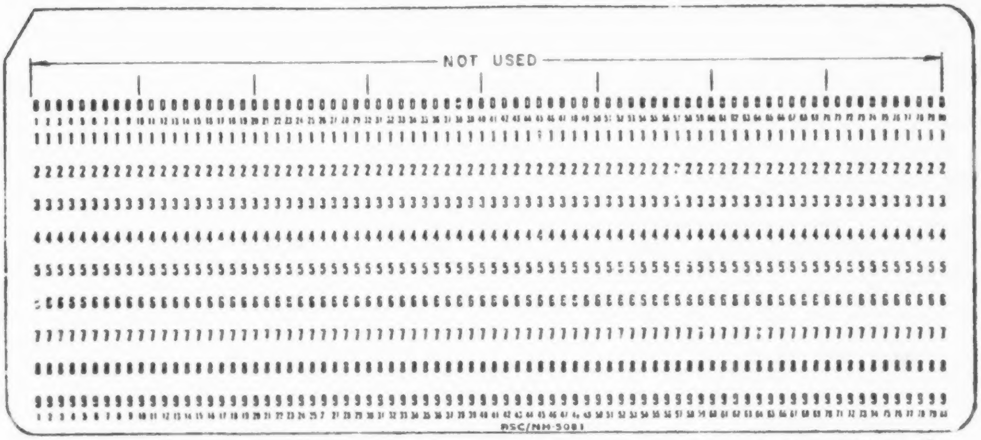


Format (A10, 7E10.0)

VARIABLE	DEFINITION
PARAM(K)	Descriptive identifier for solid component (K). PARAM(K) can be any numeric and/or alphabetical combination.
ROAS(K)	Solid density of solid component (K). ROAS is defined in gm/cc.
CS(K)	Concentration of solid component (K) in bulk cloud.
VFALL(K)	Fall velocity of solid component (K). VFALL is defined in ft/sec. (see Appendix D).
VOIDS(K)	Voids ratio of solid component (K). (See Appendix D).
ICOHES(K)	If ICOHES equals zero the cohesive model in the long term diffusion phase is bypassed. If ICOHES equals one the long term diffusion phase employs the cohesiveness.

Card Fourteen will be repeated NS times.

Figure 45. Input Card Number Fifteen, Simplified Input/Output



Format (A10, 2E10.0)

VOLUME	DEFINITION
	Since KEY3 = 0, a blank card may be used for card number fifteen.

Figure 46. Input Card Number Sixteen, Simplified Input/Output

SECTION 4

DESCRIPTION OF WORKBOOK, TABLES AND EXAMPLES

A. General Description

There are many people who need information regarding the fate of dredged materials discharged into a water column and do not have the capabilities or facilities to run large computer models. Through the use of pre-calculated values, this section provides information which approximates desired characteristics of discharged materials. This information is found in a series of tables containing the predicted fate of dredged material as calculated by the model described in this report for a wide matrix of input conditions. The input values, as well as the resulting computer output, have been non-dimensionalized in order to have them as general as possible and applicable to any set of units.

Due to the large number of variables involved, restrictions were established to keep the report within a reasonable length. Discharged material variables considered were bulk density, volume, composition and liquid limit. Receiving water variables considered were density, current velocity and depth. Limitations on variables considered are as follows:

Three bulk densities were considered. When expressed in dimensionless form as excess density, $(\rho_o - \rho_a)/\rho_a = \rho'$ these three values were 0.4, 0.25, and 0.10. The initial dump is assumed to be hemispherical in shape after release. Thus, the diameter, $D = (12V/\pi)^{1/3}$, was selected as a scaling variable where V is the volume of the dump.

The composition of the dumped material was assumed to be primarily of three types of material: a) fine gravel or coarse sand of 1,000 to 10,000 μ equivalent diameter that has a fall velocity of 0.15 m/s (0.5 ft/s), b) fine to medium sand of 200-300 μ sphere diameter with a fall velocity of .015 m/s (.05 ft/s), and c) silt or clay of 30-40μ diameter with a fall velocity of .0003 m/s (.001 ft/s). The density of all solid material was assumed to be 2.65 gm/cc. Variations in components a, b, and c are as follows: equal concentration of all three components coded 3-3-3; 80% component a and 20% component b coded 8-2-0; 10% component a, 80% component b and 10% component c coded 1-8-1, and finally 20% component b and 80% component c coded 0-2-8. Thus 8-2-0 is primarily gravel with a little sand whereas 0-2-8 is primarily silt or clay with a little sand and 1-8-1 is primarily sand with a little gravel and silt.

The liquid limit of the dumped material as defined earlier was assumed to be either 40, 80, or 120. Due to the inconsistency of high liquid limit with low bulk density and large particles, only realistic combinations of bulk density, liquid limit and composition were considered.

The ambient receiving water velocity, Ua was assumed to be constant and have a profile as shown in Figure 47, where H is the ambient water column depth. Variation in Ua were expressed as the dimensionless variable $R = Ua/(Dg\,\rho')^{1/2}$ where g is the gravitational constant. The other variables have been

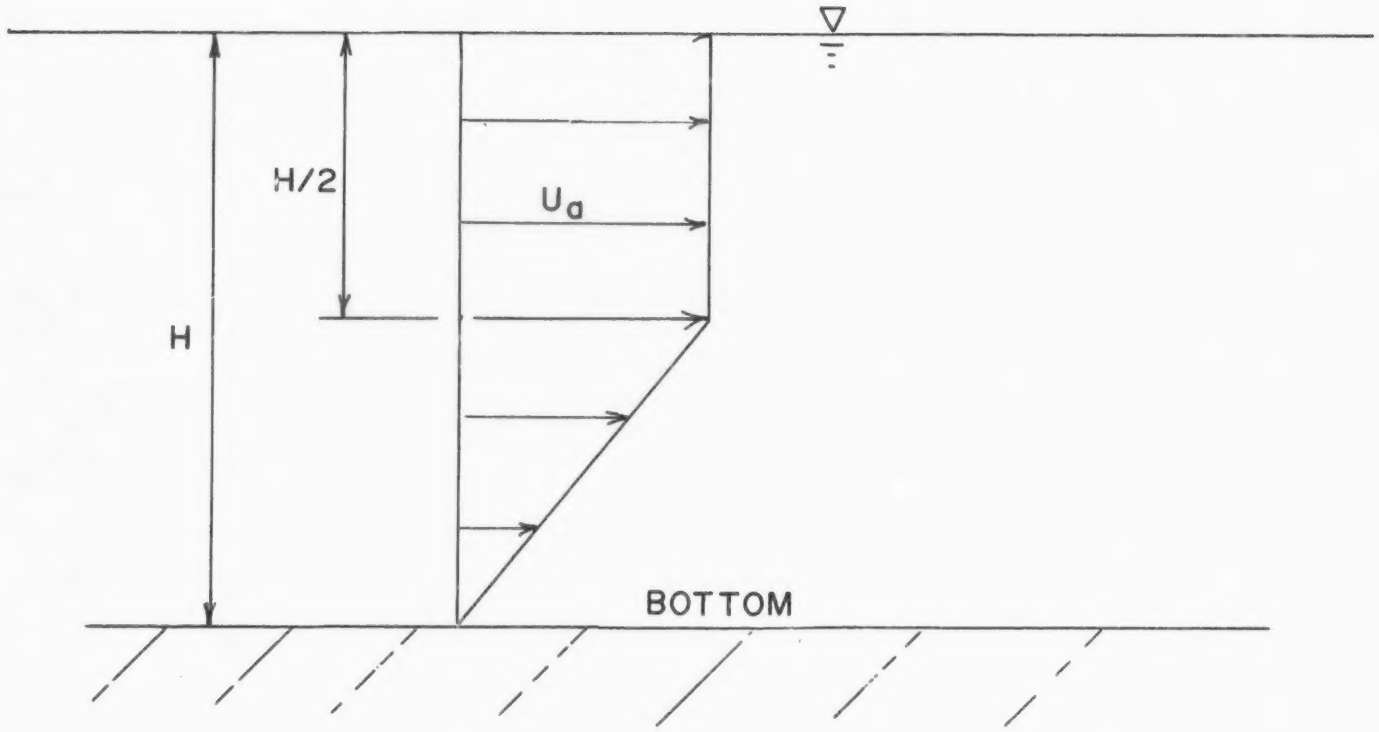

H/2
U_a
H
BOTTOM

Figure 47. Assumed ambient velocity profile for workbook tables.

defined previously. R values of 0, 0.02, 0.1 and 0.5 were considered. Since most of the solid particles of a dredged material are only slightly affected by ambient stratification, a uniform density ambient was assumed.

The depth of the water column is assumed to be constant. Depths of 5, 10, and 20 times the initial dump diameter, D, were considered. Tables 17 and 18 give the input variables in matrix form. Also given are the table numbers where the output is found corresponding to combinations of these input variables. Since barge velocity and initial downward velocity of the dump have little effect on the ultimate fate of the dumped material, they have both been set at zero.

The procedure for locating the table where the output can be found corresponding to a desired set of input conditions is as follows:

1. From preliminary tests, determine the liquid limit, LL, of the material to be dumped. If the liquid limit of the material cannot be determined, use LL=120 for materials that are cohesive and fall as a clump when released. Use LL=40 for materials that are non-cohesive and for materials with high moisture content giving low initial density differences. For materials that are only moderately cohesive with high initial density difference (of the order of 0.4) use LL=80.

2. Determine the approximate composition of the material as to gravel, sand and silt, such as 10% gravel, 80% sand, and 10% silt, 1-8-1.

3. Determine the density of material to be released and of the receiving water and determine excess density ratio $\rho' = (\rho_o - \rho_a)/\rho_a$.

4. From the volume of material to be dumped, determine effective hemispherical diameter $D = (12V/\pi)^{1/3}$.

5. From ambient current Ua, determine $R = Ua/(gD\rho')^{1/2}$.
   Use g = 32.2 for Ua in ft/s and D in ft.
   Use g = 9.8 for Ua in m/s and D in meters.

6. From depth of receiving water determine H = depth/D.

7. From LL determine correct set of sub matrices (Tables 17 or 18).

8. From composition and excess density ratio determine correct submatrix.

9. From R and H determine table where output values are listed for case in question.

For example for LL = 40, $\rho' = 0.4$, composition = 3-3-3, R = 0.1, and H = 10, see Table 20. For most cases, exact agreement between desired values and input values used for generating the tables will not be reached. Using the closest tabulated values will yield satisfactory results in most cases. Higher accuracy can be obtained by interpolating between tabulated values.

Output Variables

The characteristics of the discharged material after it has diffused with the ambient and settled to the bottom are presented in the tables as a function of time after being dumped.

The variables presented are location, extent and maximum thickness of material settled on the bottom; and location, extent and maximum concentration of the suspended cloud. Unfortunately, the program would not run for a few of the cases. In addition, during transition from dynamic calculations to long-term diffusion, the program divides the suspended material into a series of small clouds that grow and diffuse with time. When the size of a particular small cloud exceeds the size of the long-term diffusion grid, it is injected into the long-term grid for further calculations. If small clouds still exist when printout occurs, the concentrations given are in error. As a result, concentrations for many cases have been omitted. Settled material information for these cases is correct and has been given.

Output variables are all dimensionless as follows:

1. Time is given as $T = \Theta\ (g\rho'/D)^{1/2}$

   where Θ is the time from discharge in seconds.

2. Xm is the distance from the point of discharge (divided by the diameter D) to the point of maximum thickness of material settled on the bottom,

3. X_o is the distance from the point of discharge to the centroid of the settled material divided by D.

4. The shape of settled material on the bottom has been approximated by an ellipse having total major and minor axes of A and B, respectively. The boundary of the ellipse is defined when the thickness of the material settled on the bottom is approximately 0.01 times the maximum mound thickness. This is shown in Figure 48. Again, all lengths and thicknesses have been normalized by the diameter D.

5. The normalized maximum mound height is given by the symbol t. Intermediate thickness can be approximated by assuming a Gaussian distribution from the maximum thickness to the edge. This assumption gives the following:

   a. At one-fourth of the distance from the maximum mound thickness to the edge, the thickness will be 0.75t.

   b. At one-half the distance from the maximum thickness to the edge, the thickness will be 0.32t.

   c. At three-fourths the distance from the maximum thickness to the edge, the thickness will be 0.07t.

5. The values of Xm, X_o, A, and B are also given for the suspended cloud when meaningful information could be calculated. The value,

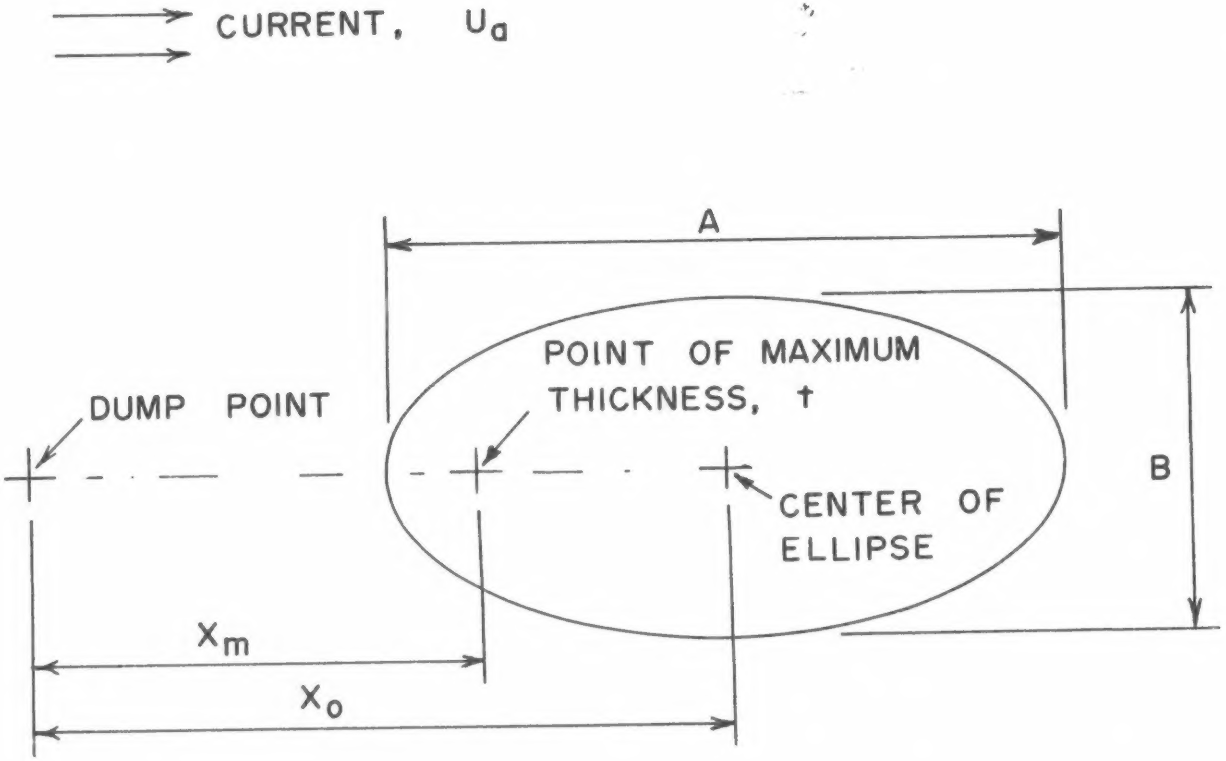

CURRENT, U_a
DUMP POINT
POINT OF MAXIMUM THICKNESS, t
CENTER OF ELLIPSE
A
B
X_m
X_o

Figure 48. Definition Ellipse for material settled on bottom.

Xm is the horizontal distance from the point of discharge to the point of maximum concentration of the cloud. The maximum concentration, Cm, is given as a volume fraction of suspended material to the total. The vertical location and thickness of the cloud have not been given since this information was not reliable.

B. Examples of Use

The accuracy of the prediction obtained from this model will depend to a great extent on how well the actual dump matches the assumptions used in the model. Users should, therefore, realize that large deviations from the conditions used in the model will result in considerable error. For example, it is very difficult to have an instantaneous dump. However, for a barge dump, the material leaves fairly quickly and can be approximated by an instantaneous release. Care must also be taken in determining material properties and ambient conditions.

The following examples have been given to familiarize the reader with the use of the tables. An attempt was made to develop more or less realistic problem statements. However, due to the wide variety in variables, only a limited number are presented. For the sake of calculation, many numbers have been conveniently rounded off.

Example #1

A barge contains 200 cu yd of dredged material consisting of 20% silt-clay, 8% sand and 72% water by volume. The bulk density is 1.46. With this composition, 29% of the solid material is sand and 71% silt-clay. The dump site is 110 ft deep and the average current is one-knot. The ambient density is 1.02. The liquid limit of the dredged material is 53.

It is desired to know where the material will settle on the bottom as time progresses, and the maximum concentration of the suspended cloud as it passes in imaginary vertical plane 1/2 mile from the dump site.

Solution:

Determine input parameters:

Effective Diameter

$$\text{Volume} = 200 \text{ yds}^3 \times 27 \text{ ft}^3/\text{yd}^3 = 5400 \text{ ft}^3$$

$$D = (12 \times 5400/\pi)^{1/3} = 27.42 \text{ ft}$$

Excess density ratio

$$\rho' = (1.46 - 1.02)/1.02 = 0.43$$

Depth

$$H = 110/27.42 = 4.01$$

Dimensionless current

$$R = Ua/(gD\rho')^{1/2}$$

$$Ua = 1.0 \text{ knot} = 1.688 \text{ ft/s}$$

$$R = 1.638/(32.2 \times 27.4 \times .43)^{1/2} = 0.09$$

The closest tabulated input values to these are LL = 40, 0-2-8 composition, $\rho' = 0.4$, R = 0.1 and H = 5.

From reference Table 17 the tabulated output for these conditions is found on Table 46. For the settled material the following values are found:

	Xm	X_o	A	B	t
T = 400	0	10	30	30	3.7 E-5
T = 800	0	25	60	30	3.7 E-5
T = 1200	0	45	105	35	3.7 E-5
T = 1600	0	65	130	40	3.7 E-5

Since T is defined as $\Theta\ (g\rho'/D)^{1/2}$, the time

$$\Theta\ (\text{sec}) = T/\ (g\rho'/D)^{1/2}$$

Therefore T = 400 corresponds to a

time of $\Theta = 400/(32.2 \times .43/27.4)^{1/2} = 562.7 \text{ sec} \cong 10 \text{ min}$

$T = 800 \cong 20$ min
$T = 1200 \cong 30$ min
$T = 1600 \cong 40$ min

With D = 27.4 ft, the values for this case are:

Time (min)	Xm (ft)	Xo (ft)	A (ft)	B (ft)	Thickness (ft)
10	0	274	822	822	.001
20	0	685	1649	822	.001
30	0	1233	2802	959	.001
40	0	1781	3562	1086	.001

This can be plotted to give the approximate shape of the settled material at the given time as shown in Figure 49.

The maximum concentration of the cloud is located 80 x 27.4 = 2,192 ft downstream 30 min after the dump, and 110 x 27.4 = 3,014 ft downstream 40 minutes after the dump. The maximum concentration is about 3.7×10^{-5} for both cases. Since 1/2 mile is 2,640 ft, the maximum concentration of the cloud as it passes this point is about $3.7 \times 10^{-5}\ \text{ft}^3/\text{ft}^3$.

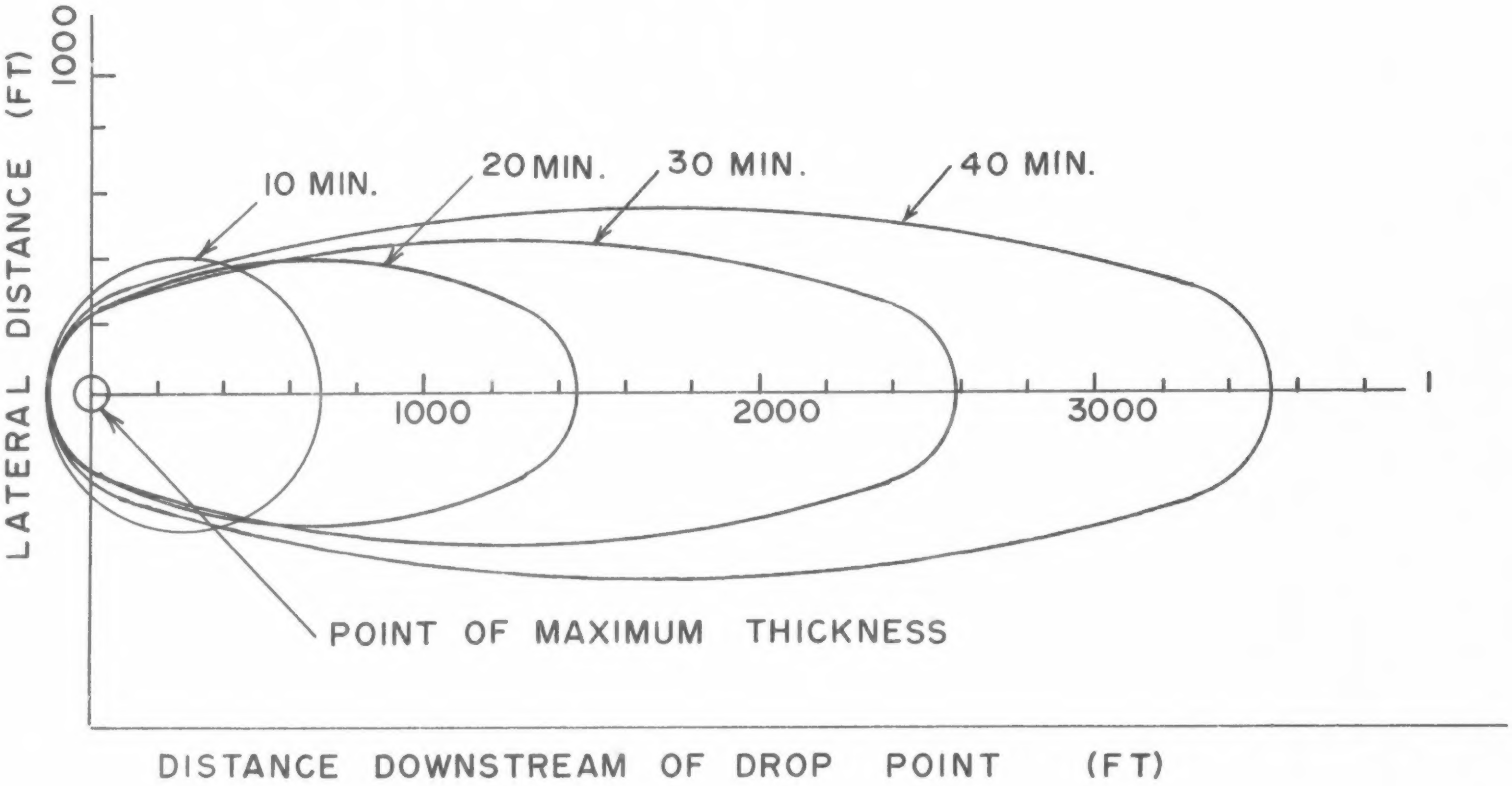


Figure 49. Predicted shape and location of material settled on bottom for example #1.

Example #2

A 500 m^3 barge contains dredged material in five separate hoppers, each containing 100 m^3. The makeup of the material in each hopper is as follows:

Hopper	Bulk Density	Gravel	Sand	Silt	Liquid	LL
1	1.25	5%	5%	5%	85%	40
2	1.25	5%	5%	5%	85%	40
3	1.4	2%	20%	2%	76%	40
4	1.4	2%	20%	2%	76%	40
5	1.4	0%	4%	20%	76%	120

The hopper doors are opened simultaneously at a dump site that is 90 m deep. The average ambient current and density at the site are 25 cm/s and 1.025, respectively.

Determine the location and distribution of settled material on the bottom twenty minutes after release.

Solution:

There are three different ways the five hopper release can be handled. One is to treat each independently, another is to lump them all together into one equivalent dump, and the third is to lump like material together and treat them separately, i.e., treat hoppers 1 and 2 as one, 3 and 4 as one, and 5 as one.

The third method is probably the most realistic in this case. It will be used in the example.

Hoppers 1 and 2

Determine equivalent hemispherical diameter;

$$D = (12 \times 200/\pi)^{1/3} = 9.14 \text{ m}$$

Excess density ratio:

$$\rho' = (1.25 - 1.025)/1.025 = 0.22$$

Dimensionless depth:

$$H = 90/9.14 = 9.8$$

Dimensionless current:

$$R = 0.25/(9.8 \times 9.14 \times .22)^{1/2} = .056$$

Composition:

With equal parts gravel, sand, and silt, use 3-3-3

The closest tabulated input values are LL = 40, 3-3-3, $\rho' = 0.25$, H = 10, and R between 0.02 and 0.1. For R = 0.02 the correct table is 39. For a time of 20 minutes, $T = 20 \times 60(9.8 \times .22/9.14)^{1/2}$ or $T = 583 \cong 600$. From the table, it is found that:

$Xm = 5$ or $5 \times 9.14 = 46$ m
$Xo = 5 \quad = 46$ m
$A = 40 \quad = 366$ m
$B = 30 \quad = 279$ m
$t = 5.2 \times 10^{-5} \quad = .000475$ m

For $R = 0.1$ use Table 40, where the following are found

$Xm = 10$ or $10 \times 9.14 = 91$ m
$Xo = 35 \quad = 320$ m
$A = 70 \quad = 640$ m
$B = 50 \quad = 460$ m
$t = 1.9 \times 10^{-5} \quad = .000174$ m

Linearly interpolating between these values to an $R = .056$ yield

$Xm = 66$ m
$Xo = 169$ m
$A = 489$ m
$B = 358$ m
$t = .00034$ m

Interpolation between the other input variables could be done if the user wished.

Hoppers 3 and 4 $\quad D = 9.14$
Excess Density: $\quad \rho' = (1.4 - 1.025/1.025) = 0.37$
Dimensionless Depth: $\quad H = 9.8$ same as 1 and 2
Dimensionless Current: $\quad R = 0.25/(9.8 \times 9.14 \times 0.37)^{1/2} = .043$
Composition:

With the mixture being 2% gravel, 20% sand and 2% silt, the solids composition is $(2/24) \times 100 = 8.3\%$ gravel, $(20/24) \times 100 = 83\%$ sand, and $(2/24) \times 100 = 8.3\%$ silt use 10-80-10 or 1-8-1 code.

The closest input values to these are $LL = 40$, 1-8-1, $\rho' = 0.4$, $H = 10$, and R between 0.02 and 0.1. For a time of 20 minutes $T = 20 \times 60\ (9.8 \times .37/9.14)^{1/2}$ or $T = 756$. Use 800.

For $R = 0.02$ with the above conditions use Table 21, where the following are found

$Xm = 0$ or $9.14 \times 0 = 0$ m
$Xo = 5 \quad = 46$ m
$A = 40 \quad = 366$ m
$B = 30 \quad = 274$ m
$t = .00015 \quad = .00137$ m

For R = 0.1 and Table 22, the following are found

Xm = 10 = 91 m
Xo = 30 = 274 m
A = 80 = 73 m
B = 70 = 548 m
t = .000043 = .00039 m

Interpolating to a R = .043 yields

Xm = 26 m
Xo = 112 m
A = 470 m
B = 352 m
t = .0011 m

Hopper 5

Equivalent Hemispherical Density:
$D = (12 \times 100/\pi)^{1/3} = 7.26$ m

Excess Density Ratio:
$\rho' = 0.37$ (same as 3 and 4)

Dimensionless depth:
$H = 90/7.26 = 12.4$

Dimensionless Current:
$R = .25/(9.8 \times 7.26 \times .37)^{1/2} = .05$

Composition:

Since the mixture composition is 4% sand and 20% silt, the solid composition is (4/24) x 100 = 17% sand and (20/24) x 100 = 82% silt. We will use 0-2-8

The closest tabulated input values to these are: LL= 120, 0-2-8, ρ'= 0.4, H = 10 and R between .02 and 0.1. T for this case is, $T = 20 \times 60\ (9.8 \times 0.37/7.24)^{1/2} = 848$. Use 800.

For R = 0.02 use Table 37, where the following are found

Xm = 0 or 7.26 x 0 = 0 m
Xo = 3 = 22 m
A = 20 = 145 m
B = 15 = 109 m
t = 1.9×10^{-4} = .0014 m

For R = 0.1 use Table 38, in where the following are found

Xm = 0 = 0 m
Xo = 20 = 145 m
A = 40 = 290 m
B = 15 = 109 m
$t = 1.9 \times 10^{-4} = .0014$ m

Interpolating between these values to an R = 0.5 yields:

Xm = 0 m
Xo = 68 m
A = 199 m
B = 109 m
t = .0014 m

Figure 50 is a plot of the settled material for each of the three types of material considered in this example superimposed on one plot. It is noted that the high liquid limit material (120) spread much less than the low liquid limit material (40). Figure 51 is the same plot after the settled material from the three are added to give a total settled material.

Example #3

For the input condition of example #1, determine the location of the contour line where the thickness of the settled material is one-half the maximum value 40 min after the dump.

Solution:

It can be assumed with reasonable accuracy that the settled material will distribute itself such that the thickness will approximate a Gaussion curve in any particular direction. Mathematically this is:

$$t = t_{max} \text{EXP}[-(\frac{r}{b})^2]$$

Where t is the local thickness, t_{max} is the maximum thickness and be is a characteristic length in the direction of r. Since the edge of the ellipse used to approximate the edge of the settled material was selected where $t/t_{max} = 0.01$, the value of $(r/b)_{0.0}1 = 2.15$ to the edge of the ellipse. When $t/t_{max} = 0.5$ $(r/b)_{0.5} = 0.83$. Since the characteristic length b is the same in a given direction, $r_{0.5}/r_{0.01} = 0.83/2.15 \cong 0.4$. Thus, the location where the local thickness is 1/2 the maximum, is about 0.4 times the distance from the point of maximum thickness to the edge as shown in Figure 52. Other contour lines could be found in a like manner.

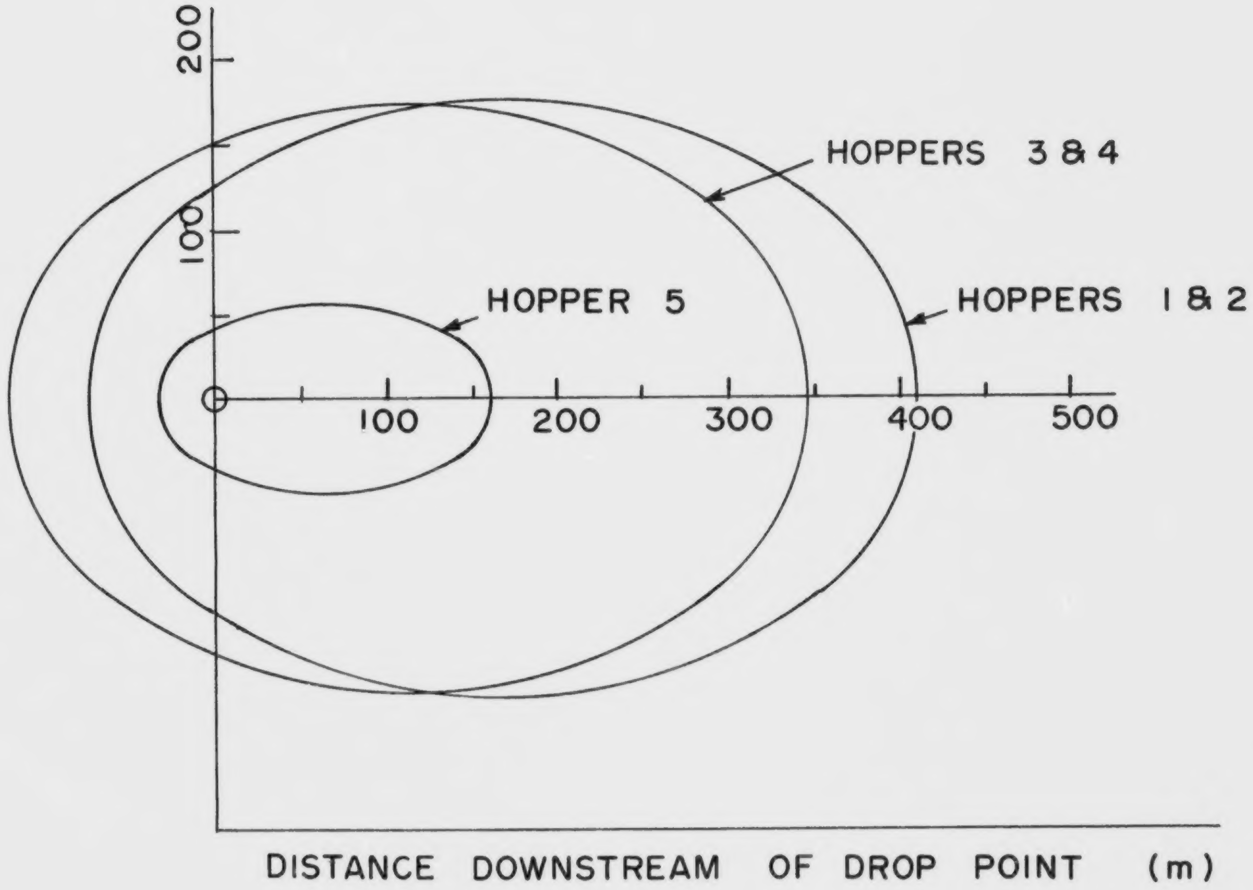


Figure 50. Predicted shape and location of different types of material settled on bottom for example #2.

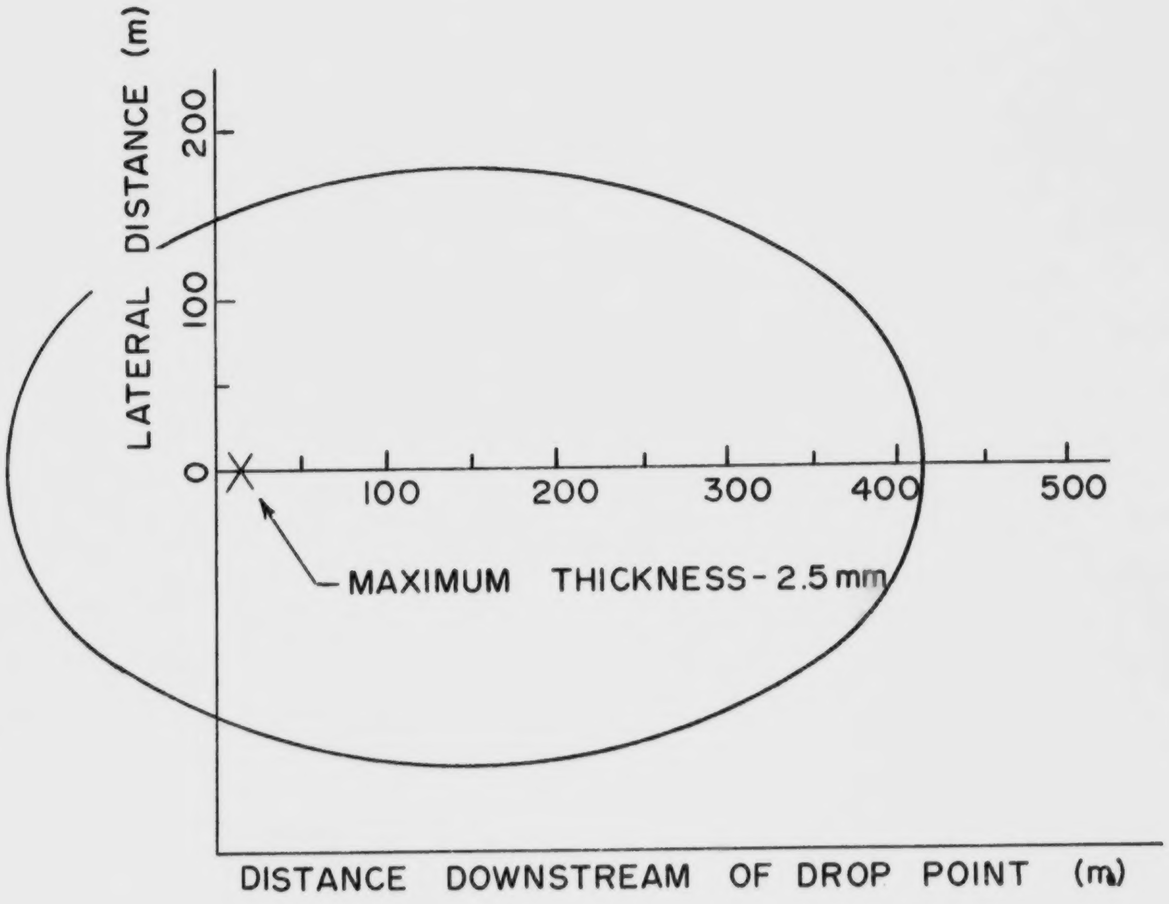


Figure 51. Composite shape, location and maximum thickness of material settled on bottom for example #2.

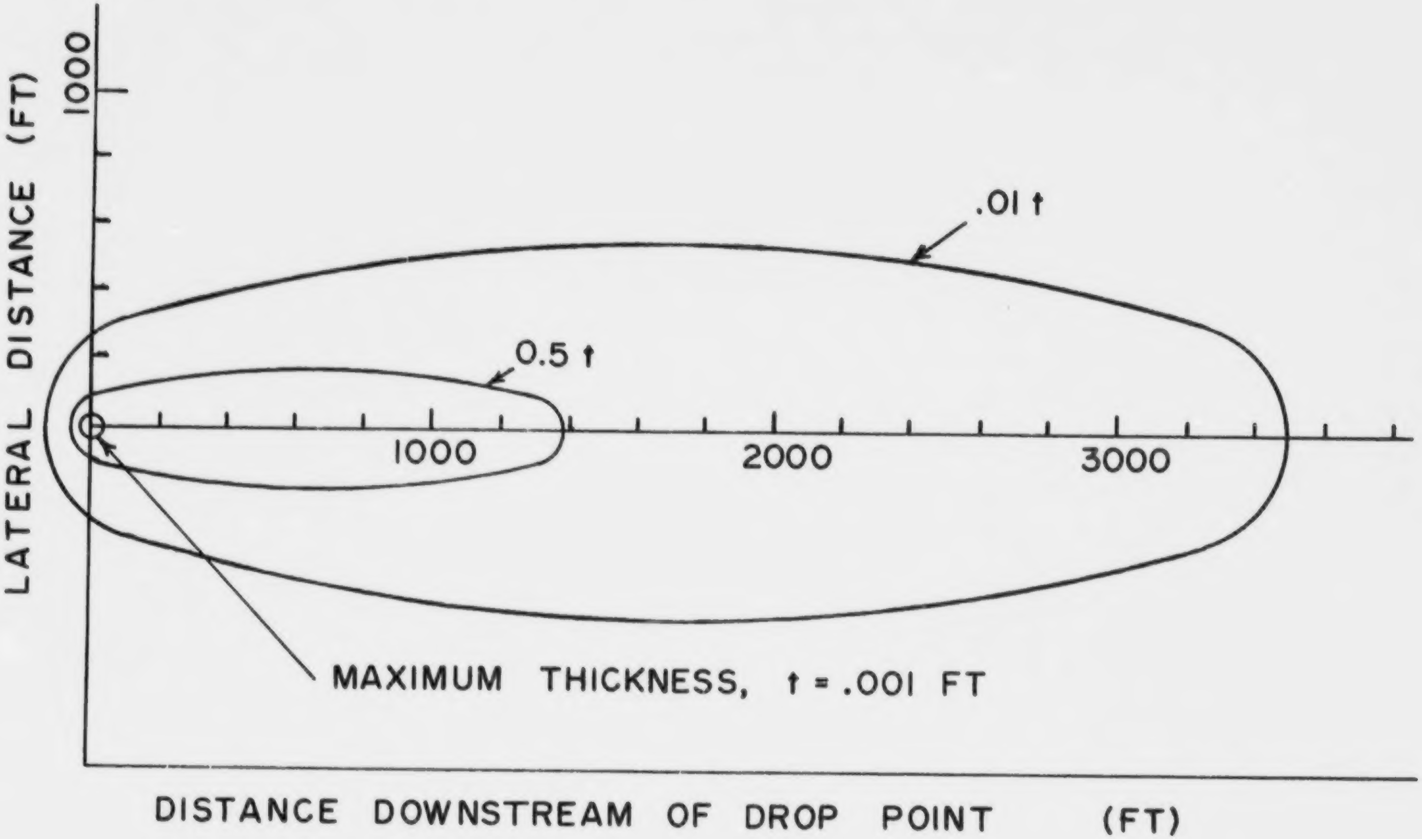


Figure 52. Contour line where thickness is one-half the maximum thickness for example #3.

C. Workbook Tables

Table 17. Cross-Reference Table for Workbook Output Table No.'s vs. Input Variables with LL = 40

		Composition 3-3-3			8-2-0			1-8-1			0-2-8		
	R \ H	5	10	20	5	10	20	5	10	20	5	10	20
ρ' = 0.4	0	19	19	19	21	21	21	23	23	23	25	25	25
	.02	19	19	19	21	21	21	23	23	23	25	25	25
	0.1	20	20	20	22	22	22	24	24	24	26	26	26
	0.5	20	20	20	22	22	22	24	24	24	26	26	26
	R \ H	5	10	20	5	10	20	5	10	20	5	10	20
ρ' = 0.25	0	39	39	39	41	41	41	43	43	43	45	45	45
	.02	29	29	29	41	41	41	43	43	43	45	45	45
	0.1	40	40		42	42	42	44	44	44	46	46	46
	0.5	40	40	40	42		42	44		44	46		36
	R \ H	5	10	20	5	10	20	5	10	20	5	10	20
ρ' = 0.1	0	47	47		49	49	49	51	51	51	53	53	53
	.02	47	47	47	49	49	49	51	51	51	53	53	53
	0.1	48	48	48	50	50		52	52	52	54	54	54
	0.5	48	48	48	50	50	50	52	52	52	54	54	54

Table 18. Cross-Reference Table for Workbook
Output Table No.'s vs. Input Variables with LL = 80 and 120

LL = 80

		Composition 3-3-3			8-2-0			1-8-1			0-2-8		
	R \ H	5	10	20	5	10	20	5	10	20	5	10	20
$\rho' = 0.4$	0	27	27	27	29	29	29	31	31	31	33	33	33
	.02	27	27	27	29	29	29	31	31	31	33	33	33
	0.1	28	28	28	30	30	30	32	32	32	34	34	34
	0.5	28	28	28	30		30	32	32	32	34	34	34

LL = 120

	Composition	1-8-1			0-2-8		
	R \ H	5	10	20	5	10	20
$\rho' = 0.4$	0	35		35	37	37	37
	.02	35	35	35	37	37	37
	0.1	36	36	36	38	38	38
	0.5	36	36	36	38	38	38

Table 19. Settled and Suspended Material Distribution for 33% Gravel, 33% Sand, 33% Silt (3-3-3), with LL = 40 and ρ' = 0.4

Dimensionless Ambient Current, R = 0

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	0	10	10	7.3E-4	0	0			
T = 800	0	0	30	30	7.4E-4	0	0	30	30	8.3E-6
T = 1200	0	0	30	30	7.4E-4	0	0	70	70	4.3E-6
T = 1600	0	0	30	30	7.4E-4	0	0	110	110	2.8E-6
H = 10										
T = 400	0	0	30	30	2.1E-4	0	0	30	30	7.3E-6
T = 800	0	0	50	50	2.3E-4	0	0	70	70	3.0E-6
T = 1200	0	0	70	70	2.4E-4	0	0	90	90	1.9E-6
T = 1600	0	0	70	70	2.6E-4	0	0	110	110	1.2E-6
H = 20										
T = 400	0	0	30	30	1.0E-6	0	0	30	30	3.3E-6
T = 800	0	0	50	50	1.0E-4	0	0	70	70	1.8E-6
T = 1200	0	0	50	50	1.0E-4	0	0	90	90	1.0E-6
T = 1600	0	0	70	70	1.0E-4	0	0	120	120	7.3E-7

Dimensionless Ambient Current, R = 0.02

H = 5										
T = 1600	0	0	60	60	1.7E-4					
T = 3200	0	10	65	60	1.7E-4					
T = 4800	0	20	80	60	1.7E-4	60	60	110	60	4.4E-6
T = 6400	0	20	80	60	1.7E-4	100	90	140	80	3.6E-6
H = 10										
T = 400	0	0	30	30	1.7E-4	0	0	30	30	1.1E-5
T = 800	0	5	70	50	1.9E-4	0	0	60	50	7.9E-6
T = 1200	0	10	80	50	2.0E-4	10	10	70	50	4.6E-6
T = 1600	0	15	80	60	2.0E-4	15	15	70	50	3.5E-6
H = 20										
T = 400	0	5	30	30	1.0E-4					
T = 800	0	5	30	30	1.0E-4	10	10	50	30	1.2E-6
T = 1200	0	5	40	30	1.0E-4	10	15	80	50	8.6E-7
T = 1600	0	10	50	30	1.0E-4	10	20	100	70	5.4E-7

Table 20. Settled and Suspended Material Distribution for 33% Gravel, 33% Sand, 33% Silt (3-3-3), with LL = 40 and $\rho' = 0.4$

Dimensionless Ambient Current, R = 0.1

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	10	30	30	5.3E-4			<10	<10	
T = 800	0	15	40	30	5.3E-4	60	60	80	50	6.2E-6
T = 1200	0	40	100	30	5.3E-4	95	95	110	90	3.0E-6
T = 1600	0	45	120	30	5.4E-4	130	130	130	110	2.1E-6
H = 10										
T = 400										
T = 800	0	25	80	20	1.0E-4	60	60	100	60	3.6E-6
T = 1200	0	50	120	20	1.0E-4	100	100	120	80	2.5E-6
T = 1600	0	80	160	20	1.0E-4	140	140	140	100	1.3E-6
H = 20										
T = 400	60	160	280	80	8.0E-5					
T = 800	60	180	280	80	8.0E-5	440	280	500	140	1.2E-7
T = 1200	60	200	300	100	8.0E-5	440	300	500	160	1.2E-7
T = 1600	60	200	300	100	8.1E-5	440	340	540	180	1.2E-7

Dimensionless Ambient Current, R = 0.5

H = 5										
T = 3200	40	160	400	160	1.1E-5					
T = 6400	40	160	400	160	1.1E-5					
H = 10										
T = 3200	80	560	100	120	4.6E-6					
T = 6400	80	560	100	120	4.6E-6					
H = 20										
T = 400	150	210	210	90	3.0E-5	310	310	240	140	2.5E-7
T = 800	150	300	240	90	3.0E-5	480	480	250	150	2.1E-7
T = 1200	150	420	570	90	3.0E-5	660	660	250	150	1.8E-7
T = 1600	150	465	660	90	3.0E-5					

Table 21. Settled and Suspended Material Distribution for 80% Gravel, 20% Sand, 0% Silt (8-2-0), with LL = 40 and $\rho' = 0.4$

Dimensionless Ambient Current, R = 0

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	0	30	30	5.5E-4					
T = 800	0	0	30	30	5.7E-4					
T = 1200	0	0	30	30	5.9E-4					
T = 1600	0	0	40	40	6.0E-4	0	0	40	40	3.7E-6
H = 10										
T = 400	0	0	30	30	3.8E-4					
T = 800	0	0	35	35	3.9E-4	0	0	30	30	2.5E-6
T = 1200	0	0	40	40	4.0E-4	0	0	35	35	1.8E-6
T = 1600	0	0	40	40	4.0E-4	0	0	40	40	1.3E-6
H = 20										
T = 800	0	0	60	60	5.4E-5					
T = 1600	0	0	65	65	6.0E-5					
T = 2400	0	0	70	70	6.3E-5					
T = 3200	0	0	70	70	6.5E-5					

Dimensionless Ambient Current, R = 0.02

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	2	30	30	8.9E-4					
T = 800	0	5	40	30	9.0E-4					
T = 1200	0	5	45	35	9.0E-4	10	10	60	40	2.1E-6
T = 1600	0	10	55	35	9.0E-4	20	20	60	40	1.4E-6
H = 10										
T = 800	5	5	50	50	1.3E-4					
T = 1600	5	5	50	50	1.3E-4	0	10	50	50	1.8E-7
T = 2400	5	5	50	50	1.3E-4	10	10	70	70	5.8E-8
T = 3200	10	10	60	60	1.4E-4	15	15	75	75	2.1E-8
H = 20										
T = 800	10	10	100	100	4.1E-5					
T = 1600	10	10	110	110	4.1E-5					
T = 2400	10	10	110	110	4.1E-5					
T = 3200	10	10	110	110	4.1E-5					

Table 22. Settled and Suspended Material Distribution for 80% Gravel, 20% Sand, 0% Silt (8-2-0), with LL = 40 and $\rho' = 0.4$

Dimensionless Ambient Current, R = 0.1

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	5	10	50	30	1.6E-4					
T = 800	5	10	55	40	1.7E-4	0	5	50	40	2.6E-6
T = 1200	5	20	80	40	1.7E-4	30	40	60	40	1.0E-6
T = 1600	5	35	110	40	1.7E-4	70	70	80	60	8.9E-7
H = 10										
T = 800	20	30	80	60	1.8E-4					
T = 1600	20	30	80	60	1.8E-4	80	20	80	60	2.3E-7
T = 2400	20	30	90	60	1.8E-4	60	60	120	70	1.0E-7
T = 3200	20	40	100	60	1.8E-4	120	120	130	70	5.1E-8
H = 20										
T = 1600	240	160	300	100	1.4E-5					
T = 3200	240	160	300	100	1.4E-5					

Dimensionless Ambient Current, R = 0.5

	Settled Material					Suspended Material				
H = 5										
T = 1600	40	80	160	120	1.3E-5					
T = 3200	40	100	240	120	1.3E-5	880	880	140	50	2.3E-10
T = 4800	40	100	240	120	1.3E-5					
T = 6400	40	100	240	120	1.3E-5					
H = 10										
T = 3200	80	560	960	120	1.1E-5					
T = 6400	80	560	960	120	1.1E-5					
H = 20										
T = 400										
T = 800	360	260	200	100	5.8E-5					
T = 1200	360	310	300	100	5.8E-5					
T = 1600	360	360	400	100	5.8E-5					

Table 23. Settled and Suspended Material Distribution for 10% Gravel, 80% Sand, 10% Silt (1-8-1), with LL = 40 and ρ' = 0.4

Dimensionless Ambient Current, R = 0

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	0	30	30	1.4E-4					
T = 800	0	0	30	30	2.0E-4					
T = 1200	0	0	40	40	2.9E-4					
T = 1600	0	0	40	40	3.5E-4	0	0	40	40	2.5E-5
H = 10										
T = 400	0	0	30	30	1.1E-4					
T = 800	0	0	30	30	1.4E-4	0	0	30	30	1.0E-5
T = 1200	0	0	40	40	1.7E-4	0	0	50	50	7.7E-6
T = 1600	0	0	40	40	1.9E-4	0	0	50	50	6.2E-6
H = 20										
T = 800	0	0	60	60	2.4E-5					
T = 1600	0	0	65	65	4.3E-5					
T = 2400	0	0	70	70	5.4E-5					
T = 3200	0	0	70	70	6.1E-5					

Dimensionless Ambient Current, R = 0.02

H = 5										
T = 400	0	2	30	30	1.5E-4					
T = 800	0	5	45	30	1.9E-4					
T = 1200	0	10	55	30	2.0E-4					
T = 1600	0	15	65	40	2.0E-4	20	20	60	40	1.1E-5
H = 10										
T = 400	0	5	40	30	1.1E-4					
T = 800	0	5	40	30	1.5E-4	0	5	40	30	1.0E-5
T = 1200	0	5	40	30	1.7E-4	5	5	60	50	5.2E-6
T = 1600	0	10	50	30	1.7E-4	10	10	70	50	3.6E-6
H = 20										
T = 1600	20	10	100	100	2.6E-5					
T = 3200	20	10	110	100	2.6E-5	0	20	140	140	4.2E-8
T = 4800	20	10	110	100	2.6E-5	40	60	140	140	3.9E-8
T = 6400	20	10	110	100	2.6E-5	80	80	160	140	3.7E-8

Table 24. Settled and Suspended Material Distribution for 10% Gravel, 80% Sand, 10% Silt (1-8-1), with LL = 40 and $\rho' = 0.4$

Dimensionless Ambient Current, R = 0.1

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	5	40	30	2.3E-4					
T = 800	0	5	50	40	2.8E-4	0	5	50	40	1.2E-5
T = 1200	0	25	90	40	2.8E-4	40	40	75	60	7.3E-6
T = 1600	0	40	120	40	2.8E-4	70	80	80	60	4.3E-6
H = 10										
T = 800	10	30	80	60	3.1E-5					
T = 1600	20	35	90	70	4.3E-5	20	20	110	100	1.0E-6
T = 2400	20	40	110	80	4.3E-5	60	90	180	100	3.6E-7
T = 3200	20	60	160	80	4.3E-5	180	140	220	120	1.5E-7
H = 20										
T = 1600	60	140	280	100	1.0E-5					
T = 3200	60	140	280	120	1.0E-5	110	140	260	180	1.4E-8

Dimensionless Ambient Current, R = 0.5

	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
H = 5										
T = 1600	40	100	200	120	4.9E-5					
T = 3200	40	100	200	120	4.9E-5					
T = 4800	40	100	200	120	4.9E-5					
T = 6400	40	100	200	120	4.9E-5					
H = 10										
T = 3200	340	560	1000	120	2.3E-6					
T = 6400	340	560	1000	120	2.3E-6					

Table 25. Settled and Suspended Material Distribution for 0% Gravel, 20% Sand, 80% Silt (0-2-8), with LL = 40 and $\rho' = 0.4$

Dimensionless Ambient Current, R = 0

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	0	30	30	3.3E-5					
T = 800	0	0	30	30	5.5E-5					
T = 1200	0	0	40	40	8.0E-5					
T = 1600	0	0	40	40	1.0E-4					
H = 10										
T = 400	0	5	40	40	1.7E-5					
T = 800	0	5	45	45	2.7E-5	0	0	60	60	7.1E-6
T = 1200	0	10	50	50	3.2E-5	0	0	70	70	5.5E-6
T = 1600	0	10	60	60	3.4E-5	0	0	80	85	5.1E-6
H = 20										
T = 800	0	0	60	60	4.3E-6					
T = 1600	0	0	70	70	1.0E-5	0	0	80	80	1.3E-6
T = 2400	0	0	70	70	1.2E-5	0	0	100	100	1.1E-6
T = 3200	0	0	80	80	1.4E-5	0	0	110	110	1.0E-6

Dimensionless Ambient Current, R = .02

	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
H = 5										
T = 400	0	0	30	30	3.3E-5					
T = 800	0	5	40	30	5.0E-5					
T = 1200	0	10	55	40	5.3E-5	20	10	60	40	4.4E-5
T = 1600	0	15	65	40	5.3E-5	20	15	70	40	4.0E-5
H = 10										
T = 800	5	5	40	30	2.2E-5					
T = 1600	5	5	45	35	3.0E-5	5	5	60	50	5.0E-6
T = 2400	5	15	65	50	3.1E-5	20	20	65	55	4.4E-6
T = 3200	5	20	85	55	3.2E-5	35	35	90	75	4.1E-6
H = 20										
T = 1600	0	10	80	60	6.8E-6					
T = 3200	0	15	90	70	6.9E-6	10	10	100	100	5.6E-7
T = 4800	0	20	120	70	6.9E-6	20	20	120	100	5.4E-7
T = 6400	0	50	160	80	6.9E-6	70	70	160	110	5.2E-7

Table 26. Settled and Suspended Material Distribution for 0% Gravel, 20% Sand, 80% Silt (0-2-8), with LL = 40 and $\rho' = 0.4$

Dimensionless Ambient Current, R = 0.1

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	10	30	30	3.7E-5					
T = 800	0	25	60	30	3.7E-5					
T = 1200	0	45	105	35	3.7E-5	80	75	70	40	3.8E-5
T = 1600	0	65	130	40	3.7E-5	110	110	80	40	3.6E-5
H = 10										
T = 800	0	30	80	60	7.4E-6					
T = 1600	20	30	90	70	1.0E-5	20	20	100	70	1.4E-6
T = 2400	20	60	140	70	1.0E-5	100	100	140	100	1.2E-6
T = 3200	20	100	220	70	1.0E-5	180	180	180	110	1.2E-6
H = 20										
T = 3200	140	260	560	320	2.2E-6					
T = 6400	140	260	560	320	2.2E-6	200	280	600	440	9.3E-8
Dimensionless Ambient Current, R = 0.5										
H = 5										
T = 1600	40	60	160	120	1.2E-5					
T = 3200	40	480	960	120	1.2E-5					
T = 4800	40	480	960	120	1.2E-5					
T = 6400	40	480	960	120	1.2E-5					
H = 10										
T = 3200	340	560	1000	120	6.0E-7					
T = 6400	340	560	1000	120	6.0E-7					
H = 20										
T = 400										
T = 800	260	280	180	100	2.9E-8					
T = 1200	260	310	280	110	2.9E-8					
T = 1600	260	340	380	120	2.9E-8					

Table 27. Settled and Suspended Material Distribution for 33% Gravel, 33% Sand, 33% Silt (3-3-3), with LL = 80 and $\rho' = 0.4$

Dimensionless Ambient Current, R = 0

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	0	10	10	7.2E-4					
T = 800	0	0	10	10	7.6E-4					
T = 1200	0	0	10	10	7.6E-4	0	0	30	30	7.3E-6
T = 1600	0	0	30	30	7.6E-6	0	0	70	70	4.5E-6
H = 10										
T = 400	0	0	30	30	5.3E-4			<10	<10	
T = 800	0	0	30	30	5.6E-4	0	0	50	50	4.9E-6
T = 1200	0	0	50	50	5.7E-4	0	0	90	90	2.5E-6
T = 1600	0	0	50	50	5.8E-4	0	0	100	100	1.6E-6
H = 20										
T = 400	0	0	30	30	4.0E-4	0	0	30	30	3.2E-6
T = 800	0	0	50	50	4.1E-4	0	0	70	70	1.8E-6
T = 1200	0	0	50	50	4.1E-4	0	0	90	90	1.0E-6
T = 1600	0	0	70	70	4.2E-4	0	0	120	120	7.3E-7

Dimensionless Ambient Current, R = 0.02

	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
H = 5										
T = 400	0	0	10	10	7.3E-4					
T = 800	0	5	20	10	7.3E-4					
T = 1200	0	10	25	15	7.3E-4	15	15	50	30	7.4E-6
T = 1600	0	15	50	15	7.3E-4	25	25	100	70	3.8E-6
H = 10										
T = 400										
T = 800	0	5	25	15	3.0E-4	5	5	25	15	3.0E-5
T = 1200	5	5	25	20	3.0E-4	5	5	25	20	3.0E-5
T = 1600	5	5	30	25	3.1E-4	5	5	25	25	9.2E-6
H = 20										
T = 400	0	5	40	30	4.0E-4	5	10	50	30	3.4E-6
T = 800	0	10	50	40	4.1E-4	10	10	90	70	1.5E-6
T = 1200	0	10	70	50	4.1E-4	20	20	130	110	8.7E-7

Table 28. Settled and Suspended Material Distribution for 33% Gravel, 33% Sand, 33% Silt (3-3-3), with LL = 80 and ρ' = 0.4

Dimensionless Ambient Current, R = 0.1

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	10	40	20	1.7E-4					
T = 800	0	20	60	20	1.7E-4					
T = 1200	0	20	60	20	1.7E-4					
T = 1600	0	40	80	20	1.8E-4					
H = 10										
T = 400	0	10	40	20	1.0E-4					
T = 800	0	20	60	20	1.0E-4					
T = 1200	0	60	100	20	1.0E-4					
T = 1600	0	80	160	20	1.1E-4					
H = 20										
T = 400	0	0	30	30	4.0E-4	0	0	30	30	3.3E-6
T = 800	0	0	50	50	4.1E-4	0	0	60	60	1.8E-6
T = 1200	0	0	50	50	4.1E-41	0	0	90	90	1.0E-6
T = 1600	0	0	60	60	4.2E-4	0	0	120	120	7.3E-7

Dimensionless Ambient Current, R = 0.5

	Xm	Xo	A	B	t
H = 5					
T = 400	20	40	100	20	8-1E-5
T = 800	20	140	280	20	8.1E-5
T = 1200	20	230	420	20	8.1E-5
T = 1600	20	300	600	20	8.1E-5
H = 10					
T = 400	40	45	80	20	8.1E-5
T = 800	40	130	160	20	8.1E-5
T = 1200	40	210	440	20	8.1E-5
T = 1600	40	300	560	20	8.1E-5
H = 20					
T = 400					
T = 800	20	30	50	10	4.0E-5
T = 1200	20	50	90	10	4.0E-5
T = 1600	20	70	150	10	4.0E-5

Table 29. Settled and Suspended Material Distribution for 80% Gravel, 20% Sand, 0% Silt (8-2-0), with LL = 80 and $\rho' = 0.4$

Dimensionless Ambient Current, R = 0

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	0	10	10	1.0E-3					
T = 800	0	0	15	15	1.0E-3					
T = 1200	0	0	15	15	1.0E-3					
T = 1600	0	0	15	15	1.0E-3					
H = 10										
T = 400	0	0	30	30	5.7E-4	0	0			
T = 800	0	0	30	30	5.9E-4	0	0	30	30	4.6E-6
T = 1200	0	0	30	30	6.0E-4	0	0	30	30	3.7E-4
T = 1600	0	0	30	30	6.1E-4	0	0	35	35	3.0E-6
H = 20										
T = 400	0	0	30	30	3.2E-4					
T = 800	0	0	30	30	3.4E-4					
T = 1200	0	0	35	35	3.5E-4	0	0	35	35	2.7E-6
T = 1600	0	0	40	40	3.6E-4	0	0	40	40	2.1E-6
Dimensionless Ambient Current, R = .02										
H = 5										
T = 400	0	5	15	10	1.0E-3					
T = 800	0	5	20	15	1.0E-3					
T = 1200	0	5	20	15	1.0E-3					
T = 1600	0	5	20	15	1.0E-3					
H = 10										
T = 400	0	0	30	30	5.5E-4					
T = 800	0	5	35	30	5.6E-4	10	5	40	30	2.4E-6
T = 1200	0	5	40	30	5.6E-4	10	10	50	30	1.8E-6
T = 1600	0	10	50	30	5.7E-4	20	20	60	40	1.3E-6
H = 20										
T = 400										
T = 800	10	5	35	30	1.6E-4					
T = 1200										
T = 1600	10	5	40	35	1.7E-4					

Table 32. Settled and Suspended Material Distribution for 10% Gravel, 80% Sand, 10% Silt (1-8-1), with LL = 80 and $\rho' = 0.4$

Dimensionless Ambient Current, R = 0.1

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	15	40	30	5.8E-4					
T = 800	0	20	45	30	6.1E-4					
T = 1200	0	30	70	30	6.1E-4					
T = 1600	0	50	100	30	6.1E-4	100	100	80	40	4.3E-6
H = 10										
T = 400	0	15	40	30	2.5E-5					
T = 800	0	30	60	30	2.6E-5	30	35	40	30	1.0E-5
T = 1200	0	40	90	30	2.6E-5	70	70	70	30	8.4E-6
T = 1600	0	60	130	30	2.6E-5	100	100	70	30	6.8E-4
H = 20										
T = 400										
T = 800	10	30	70	50	6.5E-5					
T = 1200	10	30	70	50	9.0E-5					
T = 1600	10	30	70	50	1.1E-4	10	15	55	55	2.9E-5
Dimensionless Ambient Current, R = 0.5										
H = 5										
T = 400										
T = 800	30	40	80	40	8.8E-5					
T = 1200	30	90	160	40	8.8E-5					
T = 1600	30	140	260	40	8.8E-5					
H = 10										
T = 400										
T = 800	30	180	350	40	4.2E-5					
H = 20										
T = 400										
T = 800	50	240	460	80	2.9E-5					
T = 1200	50	240	460	85	3.5E-5					
T = 1600	50	260	400	80	9.0E-5					

Table 31. Settled and Suspended Material Distribution for 10% Gravel, 80% Sand, 10% Silt (1-8-1), with LL = 80 and $\rho' = 0.4$

Dimensionless Ambient Current, R = 0

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	0	30	30	5.8E-4					
T = 800	0	0	30	30	7.7E-4					
T = 1200	0	0	30	30	7.8E-4	0	0	35	35	1.3E-5
T = 1600	0	0	30	30	7.9E-4	0	0	35	35	1.1E-5
H = 10										
T = 400	0	0	30	30	1.2E-4					
T = 800	0	0	30	30	1.7E-4	0	0	30	30	2.5E-5
T = 1200	0	0	30	30	2.4E-4	0	0	30	30	2.1E-5
T = 1600	0	0	30	30	2.6E-4	0	0	30	30	1.7E-5
H = 20										
T = 400	0	0	30	30	6.4E-5					
T = 800	0	0	35	35	1.1E-4					
T = 1200	0	0	40	40	1.4E-4	0	0	50	50	6.9E-6
T = 1600	0	0	40	40	1.6E-4	0	0	60	60	4.9E-6

Dimensionless Ambient Current, R = .02

	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
H = 5										
T = 400	0	0	30	30	5.8E-4					
T = 800	0	5	35	30	7.8E-4					
T = 1200	0	5	40	30	7.8E-4					
T = 1600	0	10	50	30	7.8E-4					
H = 10										
T = 400	0	0	30	30	1.3E-4					
T = 800	0	5	40	30	1.6E-4					
T = 1200	0	10	55	30	1.7E-4	10	5	40	30	1.8E-5
T = 1600	0	10	55	35	1.7E-4	20	10	70	40	8.1E-6
H = 20										
T = 400	0	0	30	30	6.3E-5					
T = 800	0	5	40	30	1.1E-6					
T = 1200	0	5	50	35	1.3E-4	0	5	60	50	5.2E-6
T = 1600	0	5	50	35	1.4E-4	5	10	70	50	2.8E-6

Table 30. Settled and Suspended Material Distribution for 80% Gravel, 20% Sand, 0% Silt (3-3-3), with LL = 80 and ρ' = 0.4

Dimensionless Ambient Current, R = 0.1

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	5	15	15	1.0E-3					
T = 800	0	20	40	30	1.0E-3					
T = 1200	0	30	50	30	1.0E-3	60	60	50	30	4.9E-7
T = 1600	0	30	50	30	1.0E-3	90	95	70	40	3.2E-7
H = 10										
T = 400	0	10	50	30	3.2E-4					
T = 800	0	10	50	30	3.4E-4	0	10	40	30	4.0E-6
T = 1200	0	10	60	30	3.4E-4	20	20	60	35	2.2E-6
T = 1600	0	20	70	30	3.4E-4	40	40	60	35	1.2E-6
H = 20										
T = 400										
T = 800	10	15	90	50	1.3E-4					
T = 1200	10	15	95	55	1.3E-4					
T = 1600	10	15	100	60	1.3E-4	10	15	70	70	3.6E-7

Dimensionless Ambient Current, R = 0.5

	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
H = 5										
T = 400										
T = 800	20	10	80	40	1.3E-4					
T = 1200	20	35	110	40	1.3E-4					
T = 1600	20	60	140	40	1.3E-4					
H = 20										
T = 400										
T = 800	120	120	200	80	5.4E-5					
T = 1200	120	120	200	80	5.4E-5					
T = 1600	120	120	200	80	5.4E-5	50	60	100	80	1.9E-7

Table 33. Settled and Suspended Material Distribution for 0% Gravel, 20% Sand, 80% Silt (0-2-8), with LL = 80 and $\rho' = 0.4$

Dimensionless Ambient Current, R = 0

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	0	30	30	7.6E-5					
T = 800	0	0	30	30	1.3E-4					
T = 1200	0	0	30	30	1.5E-4					
T = 1600	0	0	35	35	1.6E-4	0	0	35	35	8.5E-5
H = 10										
T = 400	0	0	30	30	3.5E-5					
T = 800	0	0	30	30	4.5E-5					
T = 1200	0	0	35	35	5.7E-5	0	0	35	35	4.8E-5
T = 1600	0	0	40	40	6.7E-5	0	0	40	40	4.4E-5
H = 20										
T = 400	0	0	30	30	1.3E-5					
T = 800	0	0	35	35	2.7E-5					
T = 1200	0	0	45	45	3.5E-5	0	0	50	50	5.4E-6
T = 1600	0	0	50	50	4.0E-5	0	0	55	55	4.3E-6

Dimensionless Ambient Current, R = .02

H = 5										
T = 400	0	0	30	30	7.6E-5					
T = 800	0	5	35	30	1.3E-4					
T = 1200	0	10	40	30	1.3E-4	20	10	50	35	4.2E-5
T = 1600	0	10	50	30	1.3E-4	25	10	60	40	4.0E-5
H = 10										
T = 400	0	0	30	30	3.5E-5					
T = 800	0	10	40	30	4.1E-5					
T = 1200	0	10	50	30	4.2E-5	15	10	55	35	2.1E-5
T = 1600	0	20	60	35	4.3E-5	30	30	55	35	2.0E-5
H = 20										
T = 400	0	5	40	30	1.3E-5					
T = 800	0	5	50	40	2.7E-5	0	5	60	50	6.3E-6
T = 1200	0	10	60	50	3.3E-5	5	10	70	50	4.3E-6
T = 1600	0	10	60	50	3.6E-5	10	15	80	55	3.2E-6

Table 34. Settled and Suspended Material Distribution for 0% Gravel, 20% Sand, 80% Silt (0-2-8), with LL = 80 and ρ' = 0.4

Dimensionless Ambient Current, R = 0.1

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	5	30	30	8.0E-5					
T = 800	0	30	60	30	8.0E-5					
T = 1200	0	50	100	30	8.0E-5	70	70	50	30	4.2E-5
T = 1600	0	70	130	30	8.0E-5	110	110	70	40	3.6E-5
H = 10										
T = 400	0	5	30	30	4.0E-5					
T = 800	0	30	60	30	4.3E-5					
T = 1200	0	50	100	30	4.3E-5	80	70	70	40	2.2E-5
T = 1600	0	60	120	30	4.3E-5	110	110	80	50	1.9E-5
H = 20										
T = 400										
T = 800	10	15	40	30	2.1E-5					
T = 1200	10	15	50	35	2.6E-5					
T = 1600	10	15	55	40	3.1E-5					

Dimensionless Ambient Current, R = 0.5

	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
H = 5										
T = 400										
T = 800	10	10	60	40	2.9E-5					
T = 1200	10	50	100	40	2.9E-5					
T = 1600	10	100	140	40	2.9E-5					
H = 10										
T = 400										
T = 800	20	30	60	40	1.1E-5					
T = 1200	20	70	190	40	1.25E-5					
T = 1600	20	140	320	40	1.4E-5					
H = 20										
T = 400										
T = 800	50	60	100	80	6.9E-6					
T = 1200	60	80	130	90	8.8E-6					
T = 1600	70	100	160	100	1.0E-5	160	120	160	120	1.2E-6

Table 35. Settled and Suspended Material Distribution for 10% Gravel, 80% Sand, 10% Silt (1-8-1), with LL = 120 and ρ' = 0.4

	Settled Material					Suspended Material				
Dimensionless Ambient Current, R = 0										
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	0	15	15	1.1E-3					
T = 800	0	0	15	15	1.5E-3					
T = 1200	0	0	16	16	1.7E-3					
T = 1600	0	0	17	17	1.7E-3	0	0	30	30	4.4E-5
H = 10										
T = 400										
T = 800										
T = 1200										
T = 1600										
H = 20										
T = 400	0	0	15	15	1.0E-3					
T = 800	0	0	15	15	1.4E-3					
T = 1200	0	0	17	17	1.5E-3	0	0	25	25	3.4E-5
T = 1600	0	0	17	17	1.6E-3	0	0	30	30	2.3E-5
Dimensionless Ambient Current, R = 0.02										
H = 5										
T = 400	0	0	15	15	1.1E-3					
T = 800	0	5	20	15	1.3E-3					
T = 1200	0	5	30	17	1.3E-3	10	12	35	25	3.7E-5
T = 1600	0	10	37	20	1.3E-3	20	20	40	30	2.4E-5
H = 10										
T = 400	0	5	20	10	6.5E-4					
T = 800	0	5	20	10	1.0E-3					
T = 1200	0	5	20	10	1.0E-3					
T = 1600	0	5	20	10	1.0E-3					
H = 20										
T = 400	0	5	15	15	1.1E-3					
T = 800	0	5	20	15	1.4E-3					
T = 1200	0	5	25	17	1.5E-3	5	5	30	15	2.0E-5
T = 1600	0	7	30	20	1.5E-3	5	8	35	25	1.0E-5

Table 36. Settled and Suspended Material Distribution for 10% Gravel, 80% Sand, 10% Silt (1-8-1), with LL = 120 and ρ' = 0.4

Dimensionless Ambient Current, R = 0.1										
	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	5	15	15	1.2E-3					
T = 800	0	12	30	15	1.2E-3					
T = 1200	0	30	60	15	1.2E-3	55	60	50	25	2.4E-5
T = 1600	0	45	90	20	1.2E-3	90	100	60	30	1.3E-5
H = 10										
T = 400	0	5	20	10	6.5E-4					
T = 800	0	5	20	10	1.0E-3					
T = 1200	0	5	20	10	1.0E-3					
T = 1600	0	5	20	10	1.0E-3					
H = 20										
T = 400	0	10	20	15	1.1E-3					
T = 800	0	10	25	15	1.2E-3					
T = 1200	0	10	30	20	1.2E-3	15	22	50	17	1.5E-5
T = 1600	0	15	40	20	1.2E-3	30	45	90	30	7.6E-6
Dimensionless Ambient Current, R = 0.5										
H = 5										
T = 400	2	17	30	15	3.4E-4					
T = 800	2	17	30	15	3.4E-4					
T = 1200	2	17	30	15	3.4E-4					
T = 1600	2	17	30	15	3.4E-4					
H = 10										
T = 400	0	5	20	10	6.5E-4					
T = 800	0	5	20	10	1.0E-3					
T = 1200	0	5	20	10	1.0E-3					
T = 1600	0	5	20	10	1.0E-3					
H = 20										
T = 400	15	15	15	15	6.7E-4					
T = 800	15	35	65	15	7.1E-4					
T = 1200	15	35	65	15	7.1E-4					
T = 1600	15	35	65	15	7.1E-4					

Table 37. Settled and Suspended Material Distribution for 0% Gravel, 20% Sand, 80% Silt (0-2-8), with LL = 120 and $\rho' = 0.4$

Dimensionless Ambient Current, R = 0

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	0	15	15	1.8E-4					
T = 800	0	0	15	15	2.5E-4					
T = 1200	0	0	17	17	3.0E-4	0	0	25	25	2.5E-4
T = 1600	0	0	20	20	3.3E-4	0	0	30	30	2.0E-4
H = 10										
T = 400	0	0	15	15	1.7E-4					
T = 800	0	0	15	15	2.2E-4					
T = 1200	0	0	17	17	2.5E-4					
T = 1600	0	0	17	17	2.6E-4					
H = 20										
T = 400	0	0	15	15	1.7E-4					
T = 800	0	0	15	15	2.2E-4					
T = 1200	0	0	16	16	2.5E-4	0	0	25	25	6.9E-5
T = 1600	0	0	17	17	2.6E-4	0	0	30	30	5.4E-5

Dimensionless Ambient Current, R = .02

H = 5										
T = 400	0	0	15	15	1.8E-4					
T = 800	0	5	20	15	2.1E-4	5	12	20	15	2.1E-4
T = 1200	0	7	30	17	2.1E-4	15	15	30	17	1.3E-4
T = 1600	0	10	40	17	2.1E-4	20	20	32	25	1.1E-4
H = 10										
T = 400	0	0	15	15	1.8E-4					
T = 800	0	3	20	15	1.9E-4					
T = 1200	0	5	30	15	1.9E-4	10	12	30	25	7.1E-5
T = 1600	0	10	35	17	1.9E-4	20	20	40	30	5.6E-5
H = 20										
T = 400	0	0	15	15	1.7E-4					
T = 800	0	3	22	15	2.1E-4					
T = 1200	0	7	27	17	2.2E-4	10	10	37	25	4.3E-5
T = 1600	0	7	27	17	2.2E-4	15	15	40	30	3.0E-5

Table 38. Settled and Suspended Material Distribution
for 0% Gravel, 20% Sand, 80% Silt (0-2-8), with
LL = 120 and ρ' = 0.4

Dimensionless Ambient Current, R = 0.1

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	0	15	15	1.8E-4					
T = 800	0	15	50	15	1.8E-4					
T = 1200	0	35	85	20	1.8E-4	70	65	40	20	1.6E-4
T = 1600	0	50	120	20	1.8E-4	105	105	45	25	1.1E-6
H = 10										
T = 400	0	5	15	15	1.4E-4					
T = 800	0	20	40	15	1.9E-4					
T = 1200	0	35	75	17	1.9E-4					
T = 1600	0	60	120	17	1.9E-4	95	80	75	30	5.7E-5
H = 20										
T = 400	0	5	15	15	1.9E-4					
T = 800	0	15	30	15	2.1E-4					
T = 1200	0	25	55	20	2.1E-4	45	35	55	25	3.1E-5
T = 1600	0	35	85	20	2.1E-4	70	60	75	30	2.4E-5

Dimensionless Ambient Current, R = 0.5

H = 5										
T = 400	0	5	15	15	1.3E-4					
T = 800	0	15	35	15	1.3E-4					
T = 1200	0	15	35	15	1.3E-4					
T = 1600	0	15	35	15	1.3E-4					
H = 10										
T = 400	5	5	15	15	1.2E-4					
T = 800	5	35	70	15	1.3E-4					
T = 1200	5	35	70	15	1.3E-4					
T = 1600	5	35	70	15	1.3E-4					
H = 20										
T = 400	10	10	15	15	1.7E-4					
T = 800	10	50	85	15	1.7E-4					
T = 1200	10	60	95	15	1.7E-4					
T = 1600	10	60	95	15	1.7E-4					

Table 39. Settled and Suspended Material Distribution for 33% Gravel, 33% Sand, 33% Silt (3-3-3), with LL = 40 and $\rho' = 0.25$

Dimensionless Ambient Current, R = 0	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 300	0	0	10	10	4.5E-4					
T = 600	0	0	10	10	4.6E-4	0	0	30	30	5.2E-6
T = 900	0	0	30	30	4.6E-4	0	0	70	70	2.6E-6
T = 1200	0	0	30	30	4.6E-4	0	0	90	90	1.7E-4
H = 10										
T = 300	0	0	30	30	1.2E-4	0	0	30	30	4.6E-6
T = 600	0	0	50	50	1.4E-4	0	0	70	70	1.9E-4
T = 900	0	0	50	50	1.4E-4	0	0	90	90	1.2E-6
T = 1200	0	0	70	70	1.6E-4	0	0	120	120	7.9E-7
H = 20										
T = 300										
T = 600	0	0	30	30	3.4E-5					
T = 900	0	0	60	60	4.4E-5					
T = 1200	0	0	90	90	4.4E-5					
Dimensionless Ambient Current, R =.02										
H = 5										
T = 300	0	5	30	30	1.6E-4					
T = 600	0	10	40	30	1.7E-4					
T = 900	0	10	45	30	1.7E-4					
T = 1200	0	15	50	30	1.7E-4	20	20	60	40	1.1E-5
H = 10										
T = 600	5	5	40	30	5.2E-5					
T = 1200	5	5	45	40	6.0E-5	0	5	60	50	1.7E-6
T = 1800	5	10	55	50	6.2E-5	10	20	75	60	1.3E-6
T = 2400	5	15	70	60	6.2E-5	25	30	80	60	1.1E-6
H = 20										
T = 300										
T = 600	0	10	60	60	6.3E-5					
T = 900	0	15	80	60	6.7E-5					
T = 1200	0	20	180	60	7.7E-5	10	10	100	60	5.7E-7

Table 40. Settled and Suspended Material Distribution for 33% Gravel, 33% Sand, 33% Silt (3-3-3), with LL = 40 and ρ' = 0.25

Dimensionless Ambient Current, R = 0.1

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 300	10	10	30	30	3.0E-4					
T = 600	10	10	30	30	3.0E-4	45	45	80	50	3.5E-6
T = 900	10	10	30	30	3.0E-4	75	75	100	90	1.[illegible]E-6
T = 1200	10	10	40	30	3.3E-4	105	105	120	90	1.2E-6
H = 10										
T = 300	10	10	30	30	1.9E-4	30	35	60	30	4.6E-6
T = 600	10	35	70	50	1.9E-4	50	50	90	70	1.8E-6
T = 900	10	40	90	50	1.9E-4	70	70	110	90	1.0E-6
T = 1200	10	45	120	50	1.9E-4	90	90	140	120	6.8E-7
H = 20										
T = 300										
T = 600										
T = 900										
T = 1200										

Dimensionless Ambient Current, R = 0.5

	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
H = 5										
T = 300	50	50	150	30	2.5E-5					
T = 600	50	90	210	30	2.6E-5					
T = 900	50	150	360	30	2.6E-5					
T = 1200	50	150	360	30	2.6E-5					
H = 10										
T = 300	120	120	150	30	1.1E-5					
T = 600	180	180	390	60	1.1E-5					
T = 900	180	210	390	60	1.1E-5					
T = 1200	180	210	390	60	1.1E-5					
H = 20										
T = 300	150	210	180	90	2.0E-5					
T = 600	150	300	330	90	2.0E-5	390	390	240	150	1.2E-7
T = 900	150	360	480	90	2.0E-5	560	540	240	150	1.0E-7
T = 1200	150	450	630	90	2.0E-5	660	660	300	210	1.0E-7

Table 41. Settled and Suspended Material Distribution for 80% Gravel, 20% Sand, 0% Silt (8-2-0), with LL = 40 and $\rho' = 0.25$

Dimensionless Ambient Current, R = 0

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 300	0	0	30	30	5.8E-4					
T = 600	0	0	30	30	5.9E-4	0	0	30	30	4.1E-6
T = 900	0	0	30	30	6.0E-4	0	0	40	40	2.7E-6
T = 1200	0	0	35	35	6.1E-4	0	0	40	40	1.8E-6
H = 10										
T = 300	0	0	30	30	2.1E-4					
T = 600	0	0	40	40	2.2E-4	0	0	40	40	2.4E-6
T = 900	0	0	40	40	2.2E-4	0	0	45	45	1.9E-6
T = 1200	0	0	45	45	2.3E-4	0	0	45	45	1.6E-6
H = 20										
T = 300	0	0	30	30	2.1E-4					
T = 600	0	0	35	35	2.2E-4	0	0	40	40	2.4E-6
T = 900	0	0	40	40	2.2E-4	0	0	40	40	1.9E-6
T = 1200	0	0	40	40	2.3E-4	0	0	40	40	1.6E-6

Dimensionless Ambient Current, R = .02

	Settled Material					Suspended Material				
	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
H = 5										
T = 300	0	0	30	30	5.4E-4					
T = 600	0	5	40	30	5.4E-4	10	5	40	30	2.6E-6
T = 900	0	10	45	30	5.4E-4	10	10	60	40	1.6E-6
T = 1200	0	10	50	30	5.4E-4	20	15	70	40	8.8E-7
H = 10										
T = 600	5	5	40	30	1.0E-4					
T = 1200	5	5	50	40	1.1E-5	0	5	60	50	5.9E-7
T = 1800	5	5	50	40	1.1E-5	10	10	70	60	2.0E-7
T = 2400	5	5	50	40	1.1E-5	10	15	80	70	8.8E-8
H = 20										
T = 2400	10	10	120	100	1.7E-5					
T = 4800	10	10	120	100	1.7E-5	20	20	180	180	9.2E-12

Table 42. Settled and Suspended Material Distribution for 80% Gravel, 20% Sand, 0% Silt (8-2-0), with LL = 40 and $\rho' = 0.25$

Dimensionless Ambient Current, R = 0.1

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 300	5	5	40	30	1.0E-4					
T = 600	5	5	40	30	1.0E-4	0	5	50	40	2.9E-6
T = 900	5	15	65	40	1.0E-4	30	30	60	40	1.7E-6
T = 1200	5	30	95	40	1.0E-4	60	50	80	60	1.0E-6
H = 10										
T = 300										
T = 600	20	25	60	50	7.1E-5					
T = 900	20	25	60	50	7.2E-5					
T = 1200	20	25	60	50	7.3E-5	10	20	70	70	1.9E-7
H = 20										
T = 300	40	20	60	60	5.8E-5					
T = 600	40	60	100	60	5.8E-5					
T = 900	40	60	100	60	5.8E-5					
T = 1200	40	60	100	60	5.8E-5					

Dimensionless Ambient Current, R = 0.5

	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
H = 5										
T = 300										
T = 600	40	60	160	40	1.9E-5					
T = 900	40	60	165	40	1.9E-5					
T = 1200	40	65	170	40	2.0E-5					
H = 10										
T = 300										
T = 600										
T = 900										
T = 1200										
H = 20										
T = 300	280	320	280	120	1.8E-5					
T = 600	280	420	520	120	1.8E-5					
T = 900	280	420	520	120	1.8E-5					
T = 1200	280	420	520	120	1.8E-5					

Table 43. Settled and Suspended Material Distribution for 10% Gravel, 80% Sand, 10% Silt (1-8-1), with LL = 40 and $\rho' = 0.25$

Dimensionless Ambient Current, R = 0

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 300	0	0	30	30	1.8E-4					
T = 600	0	0	30	30	2.1E-4	0	0	30	30	2.4E-5
T = 900	0	0	30	30	2.6E-5	0	0	40	40	1.8E-5
T = 1200	0	0	40	40	2.9E-5	0	0	40	40	1.3E-5
H = 10										
T = 300	0	0	30	30	4.8E-5					
T = 600	0	0	40	40	7.9E-5	0	0	40	40	1.0E-5
T = 900	0	0	40	40	1.0E-4	0	0	60	60	8.1E-6
T = 1200	0	0	45	45	1.2E-4	0	0	60	60	6.6E-6
H = 20										
T = 300	0	0	30	30	4.8E-5					
T = 600	0	0	40	40	7.9E-5	0	0	40	40	1.0E-5
T = 900	0	0	40	40	1.0E-4	0	0	60	60	8.1E-6
T = 1200	0	0	40	40	1.2E-4	0	0	60	60	6.6E-6

Dimensionless Ambient Current, R = .02

	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
H = 5										
T = 300	0	0	30	30	1.9E-4					
T = 600	0	5	40	30	2.2E-4	10	5	40	30	1.2E-5
T = 900	0	10	55	30	2.3E-4	10	10	60	40	8.6E-6
T = 1200	0	10	55	30	2.3E-4	20	15	70	45	5.6E-6
H = 10										
T = 300	0	5	40	30	8.0E-5					
T = 600	0	5	50	40	1.0E-4	0	5	55	50	6.5E-6
T = 900	0	5	50	40	1.1E-4	5	5	70	60	3.5E-6
T = 1200	0	5	65	40	1.2E-4	10	10	80	60	2.2E-6
H = 20										
T = 1200	0	0	120	120	2.0E-5					
T = 2400	0	20	130	120	2.1E-5					
T = 3600	0	20	130	120	2.1E-5	40	40	180	120	3.5E-8
T = 4800	0	20	130	120	2.1E-5	60	60	200	120	2.4E-8

Table 44. Settled and Suspended Material Distribution for 10% Gravel, 80% Sand, 10% Silt (1-8-1), with LL = 40 and ρ' = 0.25

Dimensionless Ambient Current, R = 0.1

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xc	A	B	Cm
T = 300	0	5	40	30	1.0E-4					
T = 600	0	5	50	35	1.2E-4	0	5	50	40	1.2E-5
T = 900	0	15	65	40	1.2E-4	35	35	70	60	7.8E-6
T = 1200	0	30	95	40	1.2E-4	60	60	80	60	4.8E-6
H = 10										
T = 300										
T = 600	20	20	80	60	1.6E-5					
T = 900	20	20	90	70	2.1E-5					
T = 1200	20	25	100	80	2.6E-5	20	30	100	80	1.0E-6
H = 20										
T = 2400	140	200	200	120	4.6E-6					
T = 4800	140	200	200	120	4.6E-6	160	200	200	120	1.2E-8

Dimensionless Ambient Current, R = 0.5

	Settled Material					Suspended Material				
H = 5										
T = 300										
T = 600	40	60	160	40	2.8E-5					
T = 900	40	60	170	40	3.0E-5					
T = 1200	40	70	180	60	3.1E-5					
H = 10										
T = 300										
T = 600										
T = 900										
T = 1200										
H = 20										
T = 300	280	320	280	120	2.2E-6					
T = 600	280	400	520	120	2.2E-6					
T = 900	280	400	520	120	2.2E-6					
T = 1200	280	400	520	120	2.2E-6					

Table 45. Settled and Suspended Material Distribution for 0% Gravel, 20% Sand, 80% Silt (0-2-8), with LL = 40 and ρ' = 0.25

Dimensionless Ambient Current, R = 0										
	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 300	0	0	30	30	1.7E-5					
T = 600	0	0	30	30	3.0E-5					
T = 900	0	0	40	40	4.6E-5	0	0	40	40	5.9E-5
T = 1200	0	0	40	40	5.6E-5	0	0	40	40	5.4E-5
H = 10										
T = 300	0	0	30	30	1.0E-5					
T = 600	0	0	40	40	1.5E-5	0	0	50	50	5.2E-6
T = 900	0	0	40	40	1.9E-5	0	0	60	60	4.7E-6
T = 1200	0	0	45	45	2.2E-5	0	0	65	65	4.5E-6
H = 20										
T = 300	0	0	30	30	1.0E-5					
T = 600	0	0	40	40	1.5E-5	0	0	50	50	5.2E-6
T = 900	0	0	45	45	1.9E-5	0	0	60	60	4.7E-5
T = 1200	0	0	45	45	2.2E-5	0	0	65	65	4.5E-5
Dimensionless Ambient Current, R = .02										
H = 5										
T = 300	0	0	30	30	1.0E-5					
T = 600	0	5	40	30	2.7E-5					
T = 900	0	10	50	40	3.0E-5					
T = 1200	0	15	70	40	3.1E-5	20	15	70	40	2.3E-5
H = 10										
T = 300	0	5	40	30	1.0E-5					
T = 600	0	5	50	40	1.6E-5	0	5	60	50	4.3E-6
T = 900	0	5	50	40	1.9E-5	5	5	80	60	3.5E-6
T = 1200	0	10	60	40	2.0E-5	10	15	90	60	3.2E-6
H = 20										
T = 1200	0	0	80	80	6.9E-6					
T = 2400	0	20	120	100	7.0E-6	40	20	160	80	4.7E-7
T = 3600	0	40	160	100	7.0E-6	60	60	160	80	3.6E-7
T = 4800	0	70	200	120	7.0E-6	80	80	200	120	3.5E-7

Table 46. Settled and Suspended Material Distribution for 0% Gravel, 20% Sand, 80% Silt (0-2-8), with LL = 40 and ρ' = 0.25

Dimensionless Ambient Current, R = 0.1

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 300	0	10	30	30	2.7E-5					
T = 600	0	30	55	30	2.9E-5					
T = 900	0	40	90	40	2.9E-5	60	60	65	40	2.6E-5
T = 1200	0	50	120	40	2.9E-5	90	85	70	40	2.3E-5
H = 10										
T = 300										
T = 600	10	30	80	60	3.6E-6					
T = 900	15	30	90	70	5.1E-6					
T = 1200	20	30	100	80	6.3E-6	20	30	100	80	1.1E-6
H = 20										
T = 2400	160	200	200	200	1.2E-6					
T = 4800	160	200	200	200	1.2E-6	200	260	280	280	7.5E-8

Dimensionless Ambient Current, R = 0.5

	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
H = 5										
T = 300										
T = 600	40	60	160	120	6.8E-6					
T = 900	40	120	300	120	7.1E-6					
T = 1200	40	220	440	120	7.5E-6					
H = 10										
T = 300										
T = 600										
T = 900										
T = 1200										
H = 20										
T = 300	400	320	280	120	9.4E-8					
T = 600	680	440	560	120	3.1E-7					
T = 900	680	440	560	120	3.1E-7					
T = 1200	680	440	560	120	3.1E-7					

Table 47. Settled and Suspended Material Distribution for 33% Gravel, 33% Sand, 33% Silt (3-3-3), with LL = 40 and ρ' = 0.1

Dimensionless Ambient Current, R = 0

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	0	30	30	2.5E-5					
T = 800	0	0	30	30	2.8E-5	0	0	30	30	1.0E-5
T = 1200	0	0	40	40	3.4E-5	0	0	50	50	8.2E-6
T = 1600	0	0	40	40	3.7E-5	0	0	60	60	7.0E-6
H = 10										
T = 400	0	0	30	30	1.9E-5					
T = 800	0	0	40	40	2.3E-5	0	0	50	50	1.1E-6
T = 1200	0	0	40	40	2.6E-5	0	0	60	60	9.3E-7
T = 1600	0	0	45	45	2.7E-5	0	0	80	80	8.0E-7
H = 20										
T = 800	0	0	50	50	1.2E-5					
T = 1600	0	0	50	50	1.2E-5	0	0	70	70	1.1E-7
T = 2400	0	0	60	60	1.3E-5	0	0	80	80	1.0E-7
T = 3200	0	0	60	60	1.3E-5	0	0	100	100	1.0E-7

Dimensionless Ambient Current, R = .02

	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
H = 5										
T = 400	0	5	30	30	2.9E-5					
T = 800	0	10	45	30	3.0E-5	10	10	50	30	7.2E-6
T = 1200	5	10	55	40	3.1E-5	20	15	70	40	4.7E-6
T = 1600	5	10	65	40	3.1E-5	30	20	80	50	3.3E-6
H = 10										
T = 400	5	5	40	30	2.3E-5					
T = 800	5	5	50	40	2.6E-5	0	10	60	50	9.3E-7
T = 1200	5	5	50	40	2.8E-5	10	10	80	60	6.2E-7
T = 1600	5	5	60	40	2.8E-5	15	15	90	70	5.0E-7
H = 20										
T = 400	20	20	120	100	5.0E-6					
T = 800	20	20	120	100	5.0E-6	10	20	140	140	2.7E-8
T = 1200	20	20	120	100	5.0E-6	40	60	160	140	2.7E-8
T = 1600	20	20	120	100	5.0E-6	80	80	180	140	2.6E-8

Table 48. Settled and Suspended Material Distribution for 33% Gravel, 33% Sand, 33% Silt (3-3-3), with LL = 40 and ρ' = 0.1

Dimensionless Ambient Current, R = 0.1

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400										
T = 800	20	20	60	50	2.5E-5					
T = 1200	20	70	75	55	2.5E-5					
T = 1600	20	40	90	60	2.5E-5					
H = 10										
T = 400										
T = 800	20	30	80	60	1.3E-5					
T = 1200	20	30	80	60	1.3E-5					
T = 1600	20	30	80	60	1.3E-5					
H = 20										
T = 400										
T = 800										
T = 1200										
T = 1600										
Dimensionless Ambient Current, R = 0.5										
H = 5										
T = 400										
T = 800	120	140	260	60	1.1E-5					
T = 1200	120	150	270	60	1.1E-5					
T = 1600	120	160	280	60	1.1E-5					
H = 10										
T = 400										
T = 800	260	240	440	60	3.8E-6					
T = 1200	260	250	480	60	3.8E-6					
T = 1600	260	260	520	60	3.8E-6					
H = 20										
T = 400										
T = 800	410	360	440	100	1.2E-5					
T = 1200	410	360	440	100	1.2E-5					
T = 1600	410	360	440	100	1.2E-5					

Table 49. Settled and Suspended Material Distribution for 80% Gravel, 20% Sand, 0% Silt (8-2-0), with LL = 40 and ρ' = 0.1.4

Dimensionless Ambient Current, R = 0

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	0	30	30	3.8E-5					
T = 800	0	0	30	30	4.0E-5	0	0	30	30	5.7E-7
T = 1200	0	0	40	40	4.0E-5	0	0	40	40	1.7E-7
T = 1600	0	0	40	40	4.4E-5	0	0	70	70	5.4E-8
H = 10										
T = 400	0	0	30	30	3.1E-5					
T = 800	0	0	40	40	3.4E-5	0	0	40	40	2.9E-7
T = 1200	0	0	45	45	3.5E-5	0	0	50	50	1.7E-7
T = 1600	0	0	45	45	3.6E-5	0	0	55	55	1.0E-7
H = 20										
T = 800	0	0	60	60	9.4E-6					
T = 1600	0	0	70	70	1.0E-5	0	0	100	100	4.4E-11
T = 2400	0	0	70	70	1.0E-5	0	0	110	110	4.3E-11
T = 3200	0	0	70	70	1.0E-5	0	0	120	120	4.2E-11

Dimensionless Ambient Current, R = 0.02

H = 5										
T = 400	0	0	30	30	1.6E-4					
T = 800	0	10	40	30	1.6E-4	10	5	45	30	4.3E-7
T = 1200	0	10	45	30	1.6E-4	20	15	50	40	1.0E-7
T = 1600	0	10	45	30	1.6E-4	30	20	80	40	2.6E-8
H = 10										
T = 400	10	5	40	40	4.3E-5					
T = 800	10	5	40	40	4.4E-5	0	0	55	55	1.9E-7
T = 1200	10	5	45	45	4.4E-5	10	10	70	70	7.5E-8
T = 1600	10	10	50	50	4.5E-5	10	10	75	75	4.0E-8
H = 20										
T = 1600	40	100	160	120	8.4E-6					
T = 3200	40	110	200	120	8.4E-6	180	220	180	120	2.3E-10
T = 4800	40	120	240	120	8.4E-6	180	220	180	120	2.3E-10
T = 6400	40	120	240	120	8.4E-6					

Table 52. Settled and Suspended Material Distribution for 10% Gravel, 80% Sand, 10% Silt (1-8-1), with LL = 40 and $\rho' = 0.1$

Dimensionless Ambient Current, R = 0.1										
	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	10	70	60	4.2E-5					
T = 800	0	20	90	60	4.7E-5					
T = 1200	0	30	100	60	4.7E-5					
T = 1600	0	40	110	60	4.7E-5	120	110	140	80	3.3E-7
H = 10										
T = 800	10	30	80	60	1.0E-5					
T = 1600	10	30	90	70	1.0E-5	20	20	120	100	5.0E-8
T = 2400	10	50	120	70	1.0E-5	100	100	140	110	8.2E-8
T = 3200	10	50	120	70	1.0E-5	170	170	180	120	3.9E-8
H = 20										
T = 400										
T = 800										
T = 1200										
T = 1600										
Dimensionless Ambient Current, R = 0.5										
H = 5										
T = 800	60	160	390	60	7.1E-6					
T = 1600	60	160	390	60	7.1E-6	520	500	280	100	7.4E-8
T = 2400	60	160	390	60	7.1E-5					
T = 3200	60	160	390	60	7.1E-6					
H = 10										
T = 800										
T = 1600	720	400	800	120	2.4E-6					
T = 2400										
T = 3200	720	400	800	120	2.4E-6					
H = 20										
T = 800										
T = 1600	800	520	840	120	1.0E-6					
T = 2400										
T = 3200	800	560	920	120	1.0E-6					

Table 51. Settled and Suspended Material Distribution for 10% Gravel, 80% Sand, 10% Silt (1-8-1), with LL = 40 and $\rho' = 0.1$

	Settled Material					Suspended Material				
Dimensionless Ambient Current, R = 0.0										
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	0	30	30	2.7E-5					
T = 800	0	0	30	30	3.5E-5	0	0	30	30	5.0E-6
T = 1200	0	0	40	40	4.7E-5	0	0	35	35	3.0E-6
T = 1600	0	0	40	40	5.1E-5	0	0	40	40	2.2E-6
H = 10										
T = 400	0	0	30	30	2.1E-5					
T = 800	0	0	40	40	3.2E-5	0	0	40	40	1.3E-6
T = 1200	0	0	50	50	3.8E-5	0	0	60	60	8.9E-7
T = 1600	0	0	60	60	4.2E-5	0	0	70	70	6.0E-7
H = 20										
T = 800	0	0	60	60	6.9E-6					
T = 1600	0	0	70	70	8.4E-6	0	0	100	100	2.6E-8
T = 2400	0	0	80	80	8.5E-6	0	0	110	110	2.6E-8
T = 3200	0	0	80	80	8.5E-6	0	0	120	120	2.5E-8
Dimensionless Ambient Current, R = 0.02										
H = 5										
T = 400	0	0	30	30	3.0E-5					
T = 800	10	5	40	30	3.5E-5	10	5	40	30	3.5E-6
T = 1200	10	10	55	40	4.0E-5	20	15	70	40	1.7E-6
T = 1600	10	10	70	40	4.0E-5	25	25	70	40	1.7E-6
H = 10										
T = 400	0	5	40	30	2.3E-5					
T = 800	0	5	50	45	3.3E-5	0	5	70	70	8.8E-7
T = 1200	0	5	65	55	3.6E-5	0	10	80	80	3.4E-7
T = 1600	0	5	70	60	3.7E-5	10	15	90	80	2.0E-7
H = 20										
T = 1600	10	20	100	100	5.6E-6					
T = 3200	20	30	110	100	5.7E-6	20	20	140	140	8.3E-9
T = 4800	20	30	110	100	5.7E-6	50	50	150	140	8.1E-9
T = 6400										

Table 50. Settled and Suspended Material Distribution for 80% Gravel, 20% Sand, 0% Silt (8-2-0), with LL = 40 and ρ' = 0.1

Dimensionless Ambient Current, R = 0.1

	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	10	10	60	60	4.8E-5					
T = 800	20	30	90	60	4.8E-5					
T = 1200	20	30	90	60	4.8E-5	80	80	100	80	4.9E-9
T = 1600	20	40	100	60	4.8E-5	120	110	140	80	1.8E-9
H = 10										
T = 800	20	30	80	60	3.6E-5					
T = 1600	20	30	80	60	3.6E-5	20	30	120	100	1.0E-10
T = 2400	20	30	80	60	3.6E-5	100	100	140	120	8.5E-11
T = 3200	20	30	80	60	3.6E-5	180	180	160	120	7.5E-11
H = 20										
T = 400										
T = 800										
T = 1200										
T = 1600										

Dimensionless Ambient Current, R = 0.5

	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
H = 5										
T = 800	120	150	280	60	2.4E-5					
T = 1600	120	150	280	60	2.4E-5					
T = 2400	120	150	280	60	2.4E-5					
T = 3200	120	150	280	60	2.4E-5					
H = 10										
T = 800										
T = 1600	480	480	840	120	2.2E-6					
T = 2400										
T = 3200	480	480	840	100	2.2E-6					
H = 20										
T = 800										
T = 1600	800	500	840	120	7.8E-6					
T = 2400										
T = 3200	800	500	840	120	7.8E-6					

Table 53. Settled and Suspended Material Distribution for 0% Gravel, 20% Sand, 80% Silt (0-2-8), with LL = 40 and $\rho' = 0.1$

	Settled Material					Suspended Material				
Dimensionless Ambient Current, R = 0.0										
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	0	30	30	6.4E-6					
T = 800	0	0	30	30	9.0E-6	0	0	30	30	2.2E-5
T = 1200	0	0	40	40	1.4E-5	0	0	40	40	1.9E-5
T = 1600	0	0	40	40	1.7E-5	0	0	40	40	1.6E-5
H = 10										
T = 400	0	0	30	30	4.9E-6					
T = 800	0	0	45	45	7.5E-6	0	0	50	50	1.8E-6
T = 1200	0	0	60	60	9.4E-6	0	0	60	60	1.7E-6
T = 1600	0	0	70	70	1.0E-5	0	0	65	65	1.6E-6
H = 20										
T = 800	0	0	60	60	1.5E-6					
T = 1600	0	0	70	70	2.0E-6	0	0	100	100	2.2E-7
T = 2400	0	0	80	80	2.0E-6	0	0	110	110	2.1E-7
T = 3200	0	0	80	80	2.1E-6	0	0	120	120	2.1E-7
Dimensionless Ambient Current, R = 0.02										
H = 5										
T = 400	0	0	30	30	6.4E-6					
T = 800	10	10	50	30	7.6E-6	10	5	40	30	1.6E-5
T = 1200	10	10	60	40	1.0E-5	20	15	50	40	1.1E-5
T = 1600	10	15	65	40	1.0E-5	30	20	80	70	7.8E-6
H = 10										
T = 400	0	5	40	30	4.7E-6					
T = 800	0	5	45	40	7.4E-6	0	5	60	50	1.4E-6
T = 1200	0	10	70	60	8.3E-6	10	10	80	60	1.2E-6
T = 1600	0	10	80	65	8.6E-6	20	20	85	65	1.1E-6
H = 20										
T = 1600	0	20	100	100	1.2E-6					
T = 3200	0	20	100	100	1.3E-6	0	20	120	120	7.2E-8
T = 1200	0	40	140	110	1.3E-6	40	40	160	140	7.0E-8
T = 1600										

Table 54. Settled and Suspended Material Distribution for 0% Gravel, 20% Sand, 80% Silt (0-2-8), with LL = 40 and ρ' = 0.1

Dimensionless Ambient Current, R = 0.1										
	Settled Material					Suspended Material				
H = 5	Xm	Xo	A	B	t	Xm	Xo	A	B	Cm
T = 400	0	0	30	30	1.1E-5					
T = 800	0	30	80	60	1.3E-5					
T = 1200	0	50	110	60	1.3E-5					
T = 1600	0	70	150	60	1.3E-5	120	110	140	80	2.7E-6
H = 10										
T = 800	0	30	80	60	2.5E-6					
T = 1600	0	30	90	70	2.5E-6	20	30	120	100	4.1E-7
T = 2400	0	70	160	80	2.5E-6	100	100	140	120	3.5E-7
T = 3200	0	100	210	80	2.5E-6	170	170	180	120	3.1E-7
H = 20										
T = 400										
T = 800										
T = 1200										
T = 1600										
Dimensionless Ambient Current, R = 0.5										
H = 5										
T = 400										
T = 800	60	100	180	60	1.8E-6					
T = 1200	60	170	330	60	1.8E-6					
T = 1600	60	240	480	60	1.8E-6					
H = 10										
T = 800										
T = 1600	760	400	800	120	6.4E-7					
T = 2400										
T = 3200	760	400	800	120	6.4E-7					
H = 20										
T = 800										
T = 1600	920	480	840	120	2.3E-7					
T = 2400										
T = 3200	920	520	920	120	2.4E-7					

REFERENCES

1. Koh, R. C. Y. and Chang, Y. C., "Mathematical Model for Barged Ocean Disposal of Wastes," Environmental Protection Technology Series EPA 660/2-73-029, December 1973, U.S. EPA, Washington, D.C.

2. Brandsma, M. G. and Divoky, D. I., "Development of Models for Prediction of Short-Term Fate of Dredged Material Discharged in the Estuarine Environment," Contract Report D-76-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS, 1976.

3. Bowers, G. and Goldenblatt, M., "Calibration of a Prediction Model for Instantaneously Discharged Dredged Material," EPA-660/3-78-089, September 1978, U.S. Environmental Protection Agency, Corvallis, OR.

4. Department of the Interior, "Earth Manual," U.S. Government Printing Office, Washington, 1968.

5. Gibbs, R. J., Matthews, M. D. and Link, D. A., "The Relationship Between Sphere Size and Settling Velocity," Journal of Sedimentary Petrology, Vol. 41, No. 1, pp. 7-18, March 1971.

6. Krishnappan, B. G., "Dispersion of Granular Material in Deep Water," Canada Centre for Inland Waters Hydraulics Division Project 3-IW-HY-019.

APPENDIX

COMPUTER LISTING

```
      PROGRAM DMF(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,TAPE7)
C     DREDGED MATERIAL FATE...INSTANTANEOUS BOTTOM DUMP...
C     THIS IS DUMMY MAIN PROGRAM TO SET BLANK COMMON STORAGE POINTERS
C     FOR LONG TERM ARRAYS, SOLIDS ARRAY AND SMALL CLOUDS ARRAYS
      COMMON/DIMEN/ NS,NSP1,NVL,NSC
      COMMON/HA/AA1(4,31,31),AA2(4,31,31),AA3(4,31,31),AA4(4,31,31),
     1 KEYMAX
C     COMMON A(1)                                           C     CDC ONLY
C     COMMON A(SET DIMENSION=NEED)                                OTHERS
C     REWIND 7
      DIMENSION DEPTH(31,31)
      DIMENSION SUM(31,31),C(31,31),THICK(31,31)
     1, COUT(31,31),TOP(31,31),ACCUM(31,31)
C
C
      READ(5,15)KEYMAX
      IF(KEYMAX.NE.1)GO TO 100
      NEED = 0
      READ(5,15) NMAX,MMAX,NS,NVL,NSC
      WRITE(6,26) NMAX,MMAX,NS,NVL,NSC,NEED
   15 FORMAT(16I5)
      GO TO 110
  100 CONTINUE
      READ(5,15) NMAX,MMAX,IDEP
      NS = 3
      NVL = 1
      NSC = 20
      NEED = 0
  110 CONTINUE
      CALL MAIN(NMAX,MMAX,DEPTH,SUM,C,THICK,COUT,TOP,ACCUM,IDEP)
C     NMAX-LONG TERM ARRAY DIMENSION IN Z-DIRECTION
C     MMAX-LONG TERM ARRAY DIMENSION IN X-DIRECTION
C     NS-NUMBER OF SOLID FRACTIONS
C     NVL-NUMBER OF VELOCITY PLANES
C     NSC-MAXIMUM NUMBER OF SMALL CLOUDS ALLOWED
C
C     SET ARRAY POINTERS
C     NSP1=NS+1
C     LDIM=NMAX*MMAX
C     N1=1                                                        X
C     N2=N1+LDIM                                                  Z
C     N3=N2+LDIM                                                  DEPTH
C     N4=N3+LDIM                                                  ICODE
```

MODEL LISTING (1 of 85)

```
      C      N5=N4+LDIM                                                 CP
      C      N6=N5+LDIM                                                 THICKP
      C      N7=N6+LDIM                                                 TOPP
      C      N8=N7+LDIM                                                 SUM
      C      N9=N8+LDIM                                                 C
      C      N10=N9+LDIM                                                THICK
      C      N11=N10+LDIM                                               TOP
      C      N12=N11+LDIM                                               ACCUM
      C      N13=N12+LDIM*NS                                            U
      C      N14=N13+LDIM*NVL                                           W
      C      N15=N14+LDIM*NVL                                           SS
      C      N16=N15+600*NS                                             TSIDE
      C      N17=N16+NSC                                                TTHK
      C      N18=N17+NSC                                                TTOP
      C      N19=N18+NSC                                                TMASS
      C      N20=N19+NSC                                                TX
      C      N21=N20+NSC                                                TZ
      C      NEED=N21+NSC
      C
      C      FIND PRESENT FIELD LENGTH, ADD LENGTH OF ARRAYS(NEED) AND REQUEST CDC ONLY
      C      NEW FIELD LENGTH                                           CDC ONLY
      C      LENF=MEMGET(658) + 1                                       CDC ONLY
      C      NEWLEN=LENF+NEED                                           CDC ONLY
          26 FORMAT(/////10X,39HSTORAGE ALLOCATION PARAMETERS FOLLOW.../10X,
            1 4HNMAX,1X,4HMMAX,3X,2HNS,2X,3HNVL,2X,3HNSC,4X,4HNEED/10X,I3,2X
            2, I3,4X,I2,1X,I3,2X,I3,2X,I6 )
      C      CALL XRFL(NEWLEN)                                          CDC ONLY
      C
      C      CALL MAIN(A(N1),A(N2),A(N3),A(N4),A(N5),A(N5),A(N6),A(N7),A(N8)
      C     1, A(N9),A(N10),A(N11),A(N12),A(N13),A(N14),A(N15),A(N16),A(N17)
      C     2, A(N18),A(N19),A(N20),A(N21),NMAX,MMAX)
             CALL EXIT
             END
```

MODEL LISTING (2 of 85)

```
SUBROUTINE  MAIN                           CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.21.59.       PAGE       1
              SUBROUTINE MAIN(NMAX,MMAX,DEPTH,SUM,C,THICK,COUT,TOP,ACCUM,IDEP)
        C     SUBROUTINE MAIN(X,Z,DEPTH,ICODE,CP,COUT,THICKP,TOPP,SUM,C,THICK
        C    1, TOP,ACCUM,U,W,SS,TSIDE,TTHK,TTOP,TMASS,TX,TZ,NMAX,MMAX)
        C     MAIN PROGRAM
              COMMON/DIMEN/ NS,NSP1,NVL,NSC
              COMMON/DPASS/ NPASS,MPASS
              COMMON/BAY/ DX,DTL,XBARGE,ZBARGE,DXH,DXR,AREA
              COMMON/GUIDE1/ TDUMP,TSTOP,ISTEP,IPLUNG,NUTRL,NTRIAL,ILEAVE,
             1 KEY1,KEY2,KEY3
              COMMON/GUIDE2/NIND,NLINE(150),MF(150),ML(150)
              COMMON/AMB/  NROA,IY,Y(10),ROA(10),H
              COMMON/CLOUD/ T(600),CX(600),CY(600),CZ(600),CU(600),CV(600)
             1, CW(600),DENDIF(600),BC(600),AA(600),FC(600),VF
              COMMON/FLEF/ ITD,TD(6),DC(6),CINIT,CBACK(13),CTRACE(600)
              COMMON/GPI/ G,PI,RB
              COMMON/CHECK/TOTAL
              COMMON/LOST/ GONE
              COMMON/USERDT/ KEY4,DT1U,DT2U
              COMMON/GP/IGCN,IGCL,IGLT,IPCN,IPCL,IPLT
              COMMON/P/ PRT
              COMMON/HA/AA1(4,31,31),AA2(4,31,31),AA3(4,31,31),AA4(4,31,31),
             1 KEYMAX
              COMMON/ID/IDTL
              COMMON/PIECES/ PARAM(13),ROAS(13),CS(13),VFALL(13),VOIDS(13),BVOID
             1,ICOHES(12),VFALLC(13),VFALSC(20,13),VFALLD(31,31,13)
              LOGICAL PRT
              DIMENSION ID(8),TPRT(12)
              DIMENSION DEPTH(31,31)
              DIMENSION ICODE(31,31)
              DIMENSION SUM(31,31),C(31,31),THICK(31,31)
             1, COUT(31,31),TOP(31,31),ACCUM(31,31)
              DIMENSION U(31,31,2),W(31,31,2),SS(600,12)
              DIMENSION THICKP(31,31),TOPP(31,31),CP(31,31)
              DIMENSION TSIDE(100),TTHK(100),TTOP(100),TMASS(100),TX(100)
             1 ,TZ(100),X(31,31),Z(31,31)
        C
              DATA G,PI /32.2,3.14159/                                            NON-ANSI
              DATA  TPRT/12*0./                                                   NON-ANSI
              DATA ITD/1/,(DC(I),I=1,6)/.1,.01,.001,.0001,.00001,1.E-30/          NON-ANSI
        C
              NPASS=NMAX
              MPASS=MMAX
              NSP1=NS+1
```

MODEL LISTING (3 of 85)

```
      CALL SECOND(T1)
      IF(KEYMAX.NE.1)GO TO 10
      WRITE(6,5)
    5 FORMAT(1H1///10X,59HFATE OF DREDGED MATERIAL DEPOSITED IN AN ESTUA
     1RY BY DUMPING  )
C     READ EXECUTION MANAGEMENT PARAMETERS
      READ(5,15) KEY1,KEY2,KEY3,KEY4
      READ(5,15) IGCN,IGCL,IPCN,IPCL,IPLT,IDEP
   15 FORMAT(16I5)
      WRITE(6,25) KEY1,KEY2,KEY3,KEY4,IGCN,IGCL,IPCN,IPCL,IPLT,IDEP
   25 FORMAT(//10X,30HEXECUTION PARAMETERS FOLLOW.../10X,60HKEY1  KEY2
     1KEY3  KEY4  IGCN  IGCL  IPCN  IPCL  IPLT   IDEP  /7X,10I6)
      GO TO 20
   10 CONTINUE
      KEY1 = 1
      KEY2 = 3
      KEY3 = 0
      KEY4 = 0
      IGCN = 1
      IGCL = 1
      IPCN = 0
      IPCL = 0
      IPLT = 0
   20 CONTINUE
      IDTL = 0
C
C     READ ALPHAMERIC IDENTIFICATION FOR THIS RUN
      READ(5,35)ID
   35 FORMAT(8A10)
      WRITE(6,105) ID
  105 FORMAT(10X,8A10,//)
C
C     DEFINE ESTUARY GEOMETRY AND ARRAYS GOVERNING LONG TERM COMPUTATION
      CALL ESTGEO(DEPTH,ICODE,NMAX,MMAX,IDEP)
C
C     READ DUMP LOCATION COORDINATES AND DENSITY STRUCTURE ...
C     ...ALSO NUMBER OF VELOCITY LAYERS AND LOG PROFILE INDICATOR
      CALL AMBC(DEPTH,NMAX,MMAX,IDEP)
C
C     READ TIME OF DUMP(W/R TO START OF TIDAL CYCLE), DURATION OF
C     SIMULATION, AND TIME STEP IN LONG TERM
      READ(5,45) TDUMP,TSTOP,DTL
   45 FORMAT(8E10.0)
```

MODEL LISTING (4 of 85)

```
SUBROUTINE  MAIN                              CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.21.59.       PAGE      3
          WRITE(6,125) TDUMP,TSTOP,DTL
      125 FORMAT(///10X,25HTIME PARAMETERS FOLLOW.../10X,15HTIME OF DUMP = ,
         1 F10.2,35H SECONDS AFTER START OF TIDAL CYCLE/10X,25HDURATION OF S
         2IMULATION = ,F10.2,19H SECONDS AFTER DUMP/10X,28HLONG TERM TIME ST
         3EP (DTL) = ,F10.2,8H SECONDS)
          IF(KEY4 .EQ. 0) GO TO 124
          READ(5,45) DT1U,DT2U
          WRITE(6,119) DT1U,DT2U
      119 FORMAT(/////10X,40HINTFGRATION TIME STEPS SPECIFIED BY USER /10X
         1, 14HIN DUMP, DT = ,G14.5,5X,16HIN COLAPS, DT = ,G14.5)
      124 CONTINUE
C
C
C         SET PRINTING TIMES ACCORDING TO IPLT
          IF(IPLT)150,150,170
C         HERE TO SET DEFAULT PRINTING TIMES
      150 DTP=TSTOP/4.
          INC=DTP/DTL+.0001
          IF(DTP .LT. DTL) INC=1
          DTP=FLOAT(INC)*DTL
          DO 160 I=1,4
      160 TPRT(I)=FLOAT(I)*DTP
          IF(TPRT(4) .GT. TSTOP) TPRT(4)=TSTOP
          GO TO 180
C         HERE TO SET USER SPECIFIED PRINTING TIMES
      170 CONTINUE
          READ(5,45)( TPRT(I),I=1,IPLT)
C
C         READ INITIAL VELOCITY FIELD
      180 CALL UW(0.,U,W,NMAX,MMAX)
C         CONVECTIVE DESCENT...
          CALL DUMP(SS,U,W,DEPTH,NS,NMAX,MMAX,NVL)
          IND=NUTRL+IPLUNG
          IF(KEY2 .EQ. 1) GO TO 800
          IF(IPLUNG .EQ. 1) GO TO 250
C         CHECK DENSITY GRADIENT AT CLOUD LOCATION
          NN=NROA-1
          DO 200 I=1,NN
          IF(CY(ISTEP) .GE. Y(I) .AND. CY(ISTEP) .LE. Y(I+1)) DENGRA =
         1    ROA(I+1)-ROA(I)
      200 CONTINUE
          IF(DENGRA .GT. 1.0E-10) GO TO 250
          WRITE(6,205)
```

MODEL LISTING (5 of 85)

```
  205 FORMAT(1H1,10X,56HDENSITY GRADIENT = 0, GO DIRECTLY TO LONG TERM D
     1IFFUSION )
C       ....IF KEY2=2,TERMINATE COMPUTATION....
        IF(KEY2 .EQ. 2) 800,250
C       DYNAMIC COLLAPSE...
  250 CALL COLAPS(SS,U,W,DEPTH,NS,NMAX,MMAX,NVL)
        IF(KEY2 .EQ. 2) GO TO 800
C
C       LONG TERM DIFFUSION FOLLOWS.....
C       DETERMINE NUMBER OF COMPLETE TIDAL CYCLES AND FRACTION OF LAST
C       TIDAL CYCLE TO RUN
        TSUM=(TDUMP+TSTOP)/3600.
        NCYCLE=TSUM/25.+.0001
        XS=TDUMP+TSTOP-25.*3600.*FLOAT(NCYCLE)
        IF(NCYCLE .EQ. 0) NCYCLE=1
C       CLEAR SUM OF BOTTOM ACCUMULATION
        DO 260 M=1,MMAX
        DO 260 N=1,NMAX
  260 SUM(N,M)=0.
C
C       LOOP ON COMPONENTS
        TMAXT=0.
        TMAXI=0.
        DO 400 K=1,NSP1
        GONE=0.
        ETS=0.
        IDTL = 0
        IF(K .EQ. NSP1 .AND. KEY3 .EQ. 0) GO TO 400
        IF(KEYMAX.NE.1)GO TO 600
        WRITE(6,265) PARAM(K)
  600 CONTINUE
  265 FORMAT(1H1//10X,38HBEGIN LONG TERM SIMULATION OF FATE OF ,A10)
C       CLEAR ARRAYS
        DO 270 M=1,MMAX
        DO 270 N=1,NMAX
        C(N,M)=CBACK(K)
        THICK(N,M)=0.
        TOP(N,M)=0.
        ACCUM(N,M)=0.
  270 CONTINUE
C       DO HOOKKEEPING FOR MASS TRANSFER FROM SHORT TERM TO LONG TERM
        CALL BOOKS(K,SS,TSIDE,TTHK,TTOP,TMASS,TX,TZ,NS,DEPTH,ACCUM,U,W
       1, NMAX,MMAX,NSC,NVL)
```

MODEL LISTING (6 of 85)

```
      INDPRT=1
C
      DO 300 ICYCLE=1,NCYCLE
      IFST=1
      ILST=25.*3600./DTL + .0001
      IF(ICYCLE .EQ. 1) IFST=TDUMP/DTL + .0001
      IF(IFST .LT. 1) IFST=1
      IF(ICYCLE .EQ. NCYCLE) ILST=XS/DTL + .0001
      DO 300 IDTL2 = IFST,ILST
C     ETS IS ELAPSED TIME FROM DUMP (IN SECONDS)
      ETS=ETS+DTL
C     UPDATE VELOCITIES
      CALL UW(ETS,U,W,NMAX,MMAX)
C     SET PRINT INDICATOR PRT
      PRT=.FALSE.
      IF(ABS(ETS-TPRT(INDPRT)) .GT. .01) GO TO 280
      PRT=.TRUE.
      INDPRT=INDPRT+1
  280 CONTINUE
C     CALL ROUTINE TO MOVE AND DIFFUSE CLOUDS
      CALL MAD(K,ETS,X,Z,U,W,C,THICK,TOP,DEPTH,ACCUM,CP,THICKP,TOPP,
     1COUT,ICODE,TSIDE,TTHK,TTOP,TMASS,TX,TZ,NMAX,MMAX)
      IF(TOTAL .LT. 1.0E-06) GO TO 310
  300 CONTINUE
      TMAXI=TSTOP
C
      GO TO 330
  310 WRITE(6,315) PARAM(K),ETS
      TMAXI=AMAX1(ETS,TMAXI)
      IF(PRT.OR.KEYMAX.EQ.1)GO TO 610
      DO 1001 IDTL = IDTL,4
      DO 1001 M = 1,MMAX
      DO 1001 N = 1,NMAX
 1001 AA2(IDTL,N,M) = AA2(IDTL,N,M) + ACCUM(N,M)
  610 CONTINUE
  315 FORMAT(///18H COMPUTATIONS FOR ,A10,15H TERMINATED AT ,F10.2,
     1 48H  SEC. ELAPSED TIME...MATERIAL SETTLED TO BOTTOM)
  330 CONTINUE
C
      IF(K .EQ. NSP1) GO TO 400
C     ....HERE SAVE TOTAL ACCUMULATION (ALL COMPONENTS)
      DO 340 M=1,MMAX
      DO 340 N=1,NMAX
```

MODEL LISTING (7 of 85)

```
  340 SUM(N,M)=SUM(N,M)+ACCUM(N,M)
C     PRINT FINAL ACCUMULATED VOLUME OF THIS COMPONENT
      DO 350 M=1,MMAX
      DO 350 N=1,NMAX
  350 COUT(N,M)=ACCUM(N,M)
      IF(KEYMAX.NE.1)GO TO 620
      CALL PRINTC(COUT,NMAX,MMAX,PARAM(K),ETS,2,ICODE)
  620 CONTINUE
C     PRINT FINAL THICKNESS ACCUMULATION FOR THIS COMPONENT
      C1=(1.+VOIDS(K))/AREA
      DO 360 M=1,MMAX
      DO 360 N=1,NMAX
  360 COUT(N,M)::ACCUM(N,M)*C1
      IF(KEYMAX.NE.1)GO TO 630
      CALL PRINTC(COUT,NMAX,MMAX,PARAM(K),ETS,5,ICODE)
  630 CONTINUE
  400 CONTINUE
      TMAXF=AMAX1(TMAXT,TMAXI)
C
      IF(KEYMAX.EQ.1)GO TO 404
      DO 403 IDTL1 = 1,4
      DO 403 KK=1,5
      PAR=5HTOTAL
      DO 407 N=1,NMAX
      DO 407 M=1,MMAX
      GO TO(291,292,293,294,296),KK
  291 COUT(N,M) = AA1(IDTL1,N,M)
      GO TO 297
  292 COUT(N,M) = AA2(IDTL1,N,M)
      GO TO 297
  293 COUT(N,M) = AA3(IDTL1,N,M)
      GO TO 297
  294 COUT(N,M) = AA4(IDTL1,N,M)
      GO TO 297
  296 COUT(N,M) = AA2(IDTL1,N,M)*C1
  297 CONTINUE
  407 CONTINUE
      ETS = TSTOP*IDTL1/4.
      CALL PRINTC(COUT,NMAX,MMAX,PAR,ETS,KK,ICODE)
  403 CONTINUE
  404 CONTINUE
      ETS = TSTOP
C     ...HERE PRINT TOTAL SOLID VOLUME (ALL COMPONENTS) ACCUMULATED
```

MODEL LISTING (8 of 85)

```
      WRITE(6,405)
  405 FORMAT(1H1,/////,10X,57HFINAL DISTRIBUTIONS OF TOTAL SETTLED MATER
     1IAL FOLLOW.....  )
      DO 410 M=1,MMAX
      DO 410 N=1,NMAX
  410 COUT(N,M)=SUM(N,M)
      CALL PRINTC(COUT,NMAX,MMAX,PARAM(K),ETS,6,ICODE)
      C1=(1.+BVOID)/AREA
      DO 440 M=1,MMAX
      DO 440 N=1,NMAX
  440 COUT(N,M)= SUM(N,M)*C1
      CALL PRINTC(COUT,NMAX,MMAX,PARAM(K),ETS,7,ICODE)
      IF(KEY3 .EQ. 0) GO TO 800
C     PRINT FINAL FLUID CONCENTRATIONS
      DO 450 M=1,MMAX
      DO 450 N=1,NMAX
  450 COUT(N,M)=(C(N,M)-CBACK(NSP1))/28.31602
      CALL PRINTC(COUT,NMAX,MMAX,PARAM(NSP1),ETS,1,ICODE)
      DO 460 M=1,MMAX
      DO 460 N=1,NMAX
  460 COUT(N,M)=TOP(N,M)
      CALL PRINTC(COUT,NMAX,MMAX,PARAM(NSP1),ETS,3,ICODE)
      DO 470 M=1,MMAX
      DO 470 N=1,NMAX
  470 COUT(N,M)=THICK(N,M)
      CALL PRINTC(COUT,NMAX,MMAX,PARAM(NSP1),ETS,4,ICODE)
 1000 CINIT=CINIT/28.31602
      CBACK(NSP1)=CBACK(NSP1)/28.31602
      WRITE(6,505)PARAM(NSP1),CINIT,CBACK(NSP1)
  505 FORMAT(1H1/////10X,74HDILUTION TIMES FOR CONSERVATIVE TRACER IN IN
     1ITIAL FLUID FRACTION FOLLOW...//10X,10HTRACER IS ,A10,28H   INITIA
     2L CONCENTRATION IS ,G15.7,36H MG/L   BACKGROUND CONCENTRATION IS ,
     3  G15.7,5H MG/L )
      ITD=ITD-1
      DO 530 I=1,ITD
      IDL=1./DC(I) + .001
      WRITE(6,515) IDL,TD(I)
  515 FORMAT(10X,12HDILUTION IS ,I6,13H TO 1 WITHIN ,F10.3,19H SECONDS A
     1FTER DUMP  )
  530 CONTINUE
      WRITE(6,535)
  535 FORMAT(//10X, 54HDILUTION TIMES ARE FOR POINT OF MAXIMUM CONCENTRA
     1TION. )
  800 CALL SECOND(T2)
      T3=T2-T1
      WRITE(6,805)T3
  805 FORMAT(27H1RUN COMPLETED. CPU TIME = ,F7.3,5H SEC.)
      RETURN
      END
```

MODEL LISTING (9 of 85)

```
SUBROUTINE  ESTGEO                                 CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.21.59.        PAGE       1
              SUBROUTINE ESTGEO(DEPTH,ICODE,NMAX,MMAX,IDEP)
        C     ROUTINE TO DEFINE ESTUARY GEOMETRY AND CODED ARRAY
              COMMON/BAY/ DX,DTL,XBARGE,ZBARGE,DXH,DXR,AREA
              COMMON/GUIDE2/NIND,NLINE(150),MF(150),ML(150)
              COMMON/HA/AA1(4,31,31),AA2(4,31,31),AA3(4,31,31),AA4(4,31,31),
             1 KEYMAX
              COMMON/ID/IDTL
              DIMENSION DEPTH(31,31)
              DIMENSION ICODE(31,31)
        C     READ GRID SPACE STEP
              READ(5,45) DX
           45 FORMAT(8E10.0)
              IF(KEYMAX.NE.1)GO TO 180
              WRITE(6,65 ) NMAX,MMAX,DX
              GO TO 181
          180 WRITE(6,190)DX
          190 FORMAT(/,10X,20HGRID SPACING (DX) = ,F12.5)
          181 CONTINUE
           65 FORMAT(10X,56HNUMBER OF LONG TERM GRID POINTS IN Z-DIRECTION (NMAX
             1) = ,I3//10X,56HNUMBER OF LONG TERM GRID POINTS IN X-DIRECTION (MM
             3AX) = ,I3//10X,20HGRID SPACING (DX) = ,F12.5)
        C     SET CONSTANTS
              DXH=0.5
              DXR=1./DX
              AREA=DX**2
        C     READ DEPTHS
              IF(IDEP .EQ. 1) GO TO 200
              DO 10 M=1,MMAX
           10 READ(5,15)(DEPTH(N,M),N=1,NMAX)
           15 FORMAT(16F5.0)
              GO TO 300
          200 CONTINUE
              READ(5,15) H
              DO 210 M=1,MMAX
              DO 210 N=1,NMAX
              DEPTH(N,M)=H
          210 CONTINUE
          300 CONTINUE
        C     GENERATE CODED ARRAY
              IWPT=0
              DO 20 M=1,MMAX
              DO 20 N=1,NMAX
              ICODE(N,M)=1
```

MODEL LISTING (10 of 85)

```
      IF(DEPTH(N,M) .EQ. 0.)ICODE(N,M)=2
      IF(ICODE(N,M) .EQ. 2) GO TO 19
      IF(N.EQ. 1 .OR. N .EQ. NMAX .OR. M .EQ. 1 .OR. M .EQ. MMAX)
     1        ICODE(N,M)=3
   19 IF(ICODE(N,M) .EQ. 1) IWPT=IWPT+1
   20 CONTINUE
C     GENERATE ARRAYS GOVERNING CALCULATIONS
      NIND=0
      DO 100 N=1,NMAX
      DO 100 M=1,MMAX
      IF(ICODE(N,M) .NE. 1) GO TO 100
      IF(ICODE(N,M-1) .EQ. 1) GO TO 50
C     HERE TO START A LINE OF COMPUTATION
      NIND=NIND+1
      IF(NIND .LT. 151) GO TO 40
      WRITE(6,28)
   28 FORMAT(//2X,111HARRAYS IN COMMON BLOCK /GUIDE2/ FILLED...CALL EXIT
     1...USER SHOULD INCREASE DIMENSIONS AND CHANGE CHECK STATEMENT )
      CALL EXIT
   40 CONTINUE
      NLINE(NIND)=N
      MF(NIND)=M
      GO TO 100
   50 IF(ICODE(N,M+1) .EQ. 1) GO TO 100
C     HERE TO END A LINE OF COMPUTATION
      ML(NIND)=M
  100 CONTINUE
C     PRINT ARRAYS
      IF(KEYMAX.NE.1)GO TO 250
      WRITE(6,115)
  250 CONTINUE
  115 FORMAT(1H1,10X,21HDEPTH GRID FOLLOWS... /)
      NCP=NMAX/24+1
      IF(((NCP-1)*24) .EQ. NMAX) NCP=NCP-1
      IN2=0
      DO 130 IP=1,NCP
      IN1=IN2+1
      IN2=IN2+24
      IF(NMAX .LT. IN2) IN2=NMAX
      IF(KEYMAX.NE.1)GO TO 260
      WRITE(6,117)(N,N=IN1,IN2)
  260 CONTINUE
  117 FORMAT(2X,4HM N=,I2,24I5/)
```

```
      DO 120 M=1,MMAX
      IF(KEYMAX.NE.1)GO TO 270
      WRITE(6,119) M,(DEPTH(N,M),N=IN1,IN2)
  270 CONTINUE
  119 FORMAT(1X,I2,1X,24F5.0)
  120 CONTINUE
      IF(KEYMAX.NE.1)GO TO 273
      IF(IP .LT. NCP) WRITE(6,122)
  273 CONTINUE
  122 FORMAT(1H1//)
  130 CONTINUE
      IF(KEYMAX.NE.1)GO TO 202
      WRITE(6,135)
  202 CONTINUE
  135 FORMAT(1H1,10X,22HCODED ARRAY FOLLOWS... /)
      NCP=NMAX/60
      IF(NCP .LT. 1) NCP=1
      IN2=0
      DO 150 IP=1,NCP
      IN1=IN2+1
      IN2=IN2+60
      IF(NMAX .LT. IN2) IN2=NMAX
      IF(KEYMAX.NE.1)GO TO 213
      WRITE(6,137) IN1,IN2
  213 CONTINUE
  137 FORMAT(10X,14HRANGE OF N IS ,I3,4H TO ,I3/)
      IF(KEYMAX.NE.1)GO TO 220
      DO 140 M=1,MMAX
      WRITE(6,139)(ICODE(N,M),N=IN1,IN2)
  139 FORMAT(1X,60I2)
  140 CONTINUE
  220 CONTINUE
      IF(IP .LT. NCP) WRITE(6,122)
  150 CONTINUE
      IF(KEYMAX.NE.1)GO TO 230
      WRITE(6,155) IWPT
  230 CONTINUE
  155 FORMAT(////10X,39HNUMBER OF GRID POINTS WITHIN ESTUARY = ,I5/1H1)
      RETURN
      END
```

MODEL LISTING (12 of 85)

```
SUBROUTINE  AMBC                                    CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.21.59.      PAGE      1
                  SUBROUTINE AMBC(DEPTH,NMAX,MMAX,IDEP)
                  DIMENSION DEPTH(31,31)
                  COMMON/DIMEN/ NS,NSP1,NVL,NSC
                  COMMON/AMB/  NROA,IY,Y(10),ROA(10),H
                  COMMON/BAY/ DX,DTL,XBARGE,ZBARGE,DXH,DXR,AREA
                  COMMON/VSPECS/ IFORM,DU1,DU2,UU1,UU2,DW1,DW2,WW1,WW2,DL1,DL2
                  COMMON/HA/AA1(4,31,31),AA2(4,31,31),AA3(4,31,31),AA4(4,31,31),
                 1 KEYMAX
            C
            C     READ X AND Z COORDINATES (W/R TO LONG TERM GRID, IN FEET) OF
            C     BARGE POSITION
                  READ(5,5) XBARGE,ZBARGE
                5 FORMAT(8E10.0)
              510 CONTINUE
            C     ....READ NUMBER OF POINTS WHERE AMBIENT DENSITY SPECIFIED....
                  READ(5,15) NROA
               15 FORMAT(16I5)
            C     ....READ VERTICAL DISTANCES FROM FREE SURFACE WHERE DENSITY SPECIFIED....
                  READ(5, 5) (Y(I),I=1,NROA)
            C     ....READ AMBIENT DENSITIES....
                  READ(5, 5)(ROA(I),I=1,NROA)
            C
                  WRITE(6,25) XBARGE,ZBARGE
              520 CONTINUE
               25 FORMAT(10X,20HBARGE COORDINATES.../10X,14HXBARGE (FT) = ,G12.4
                 1, 3X,14HZBARGE (FT) = ,G12.4)
            C
            C     ....WRITE AMBIENT DENSITY PROFILE....
                  WRITE(6,35)
               35 FORMAT(//29X,24H---AMBIENT CONDITIONS---  )
                  DO 60 J=1,NROA,8
                  JJ=J+7
                  IF(JJ .GE. NROA) JJ=NROA
                  WRITE(6,45)(Y(I),I=J,JJ)
               45 FORMAT(//15X,10HDEPTH (FT),5X,8G12.4)
                  WRITE(6,55)(ROA(I),I=J,JJ)
               55 FORMAT(9X,7HAMBIENT/9X,15HDENSITY (GM/CC),5X,8G12.4)
               60 CONTINUE
            C
            C     ....CONVERT AMBIENT DENSITY FROM UNITS OF GM/CC TO SLUGS/CUFT...
                  DO 70 I=1,NROA
               70 ROA(I)=ROA(I)*1.94
            C     SET H EQUAL TO DEPTH INTERPOLATED FROM FOUR GRID POINTS SURROUNDING BARGE
```

MODEL LISTING (13 of 85)

```
      CALL DINT(XBARGE,ZBARGE,H,DEPTH,NMAX,MMAX)
      WRITE(6,75) H
   75 FORMAT(///10X,44HINTERPOLATED DEPTH AT DUMP COORDINATES, H = ,
     1 G12.4,4H FT. )
      WRITE(6,95)
   95 FORMAT(/10X,10(8H--------))
C
      READ (5,165) IFORM
  165 FORMAT(16I5)
      IF(IFORM .GE. 4) READ(5,5)  DU1,DU2,UU1,UU2,DW1,DW2,WW1,WW2
      GO TO (430,440,450,460), IFORM
  430 WRITE(6,435)
  435 FORMAT(///10X,68HSINGLE VELOCITY PLANE USED WITH VELOCITIES CONSTA
     1NT IN THE VERTICAL  )
      GO TO 480
  440 WRITE(6,445)
  445 FORMAT(///10X,53HSINGLE VELOCITY PLANE USED WITH LOGARITHMIC VELOC
     1ITY / 10X,65HDISTRIBUTION SUCH THAT VERTICAL AVERAGE EQUALS SPECIF
     2IED VELOCITY )
      GO TO 480
  450 WRITE(6,455)
  455 FORMAT(///10X,96HTWO VELOCITY PLANES USED WITH STRAIGHT LINE INTER
     1POLATION (SEE FIGURE 6.2(C) FOR INTERPRETATION) )
      GO TO 480
  460 WRITE(6,465) DU1,DU2,UU1,UU2,DW1,DW2,WW1,WW2
  465  FORMAT(//10X,73HTWO VELOCITY PROFILES SPECIFIED IN X AND Z DIRECT
     1IONS FOR --QUICK LOOKS--/10X,63HDEPTH ASSUMED CONSTANT AND VELOCIT
     2IES CONSIDERED STEADY IN TIME/10X,37HVELOCITY PROFILE PARAMETERS F
     3OLLOW... /10X,6HDU1 = ,G11.3,1X,6HDU2 = ,G11.3,1X,6HUU1 = ,G11.3,
     4 1X,6HUU2 = ,G11.3/10X,6HDW1 = ,G11.3,1X,6HDW2 = ,G11.3,1X,6HWW1 =
     5 ,G11.3,1X,6HWW2 = ,G11.3)
  480 CONTINUE
      RETURN
      END
```

MODEL LISTING (14 of 85)

```
SUBROUTINE  DUMP                                         CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.21.59.      PAGE     1
      SUBROUTINE DUMP(SS,U,W,DEPTH,NS,NMAX,MMAX,NVL)
C     THREE-DIMENSIONAL AXI-SYMMETRIC INSTANTANEOUS RELEASE OF ENTIRE
C     LOAD FROM BARGE
C
      EXTERNAL DERIVD
      DIMENSION DEPTH(31,31)
      COMMON/AMB/  NROA,IY,Y(10),ROA(10),H
      COMMON/CLOUD/T(600),CX(600),CY(600),CZ(600),CU(600),CV(600)
     1, CW(600),DENDIF(600),RC(600),AA(600),FC(600),VF
      COMMON/PIECES/ PARAM(13),ROAS(13),CS(13),VFALL(13),VOIDS(13),BVOID
     1,ICOHES(12),VFALLC(13),VFALSC(20,13),VFALLD(31,31,13)
      COMMON/GUIDE1/ TDUMP,TSTOP,ISTEP,IPLUNG,NUTRL,NTRIAL,ILEAVE,
     1 KEY1,KEY2,KEY3
      COMMON/GPI/ G,PI,RB
      COMMON/STCOEF/ ALPHA,ALPHA0,ALPHAC,BETA,CDRAG,CFRIC,CD,CD1,CD2
     1, CD3,CD4,CM,DINCR1,DINCR2,FRICTN,GAMA,F1
      COMMON/LTCOF/ ALAMDA,DIF,AKY0
      COMMON/DTEES/ DT,DT1,DT2
      COMMON/COL/ A0,IBED,FBED
      COMMON/SWITCH/ ITF
      COMMON/GP/IGCN,IGCL,IGLT,IPCN,IPCL,IPLT
      COMMON/USERDT/ KEY4,DT1U,DT2U
      COMMON/FLEE/ ITD,TD(6),DC(6),CINIT,CBACK(13),CTRACE(600)
      COMMON/COMP1/ E(22)
      COMMON/BAY/ DX,DTL,XBARGE,ZBARGE,DXH,DXR,AREA
      COMMON/HA/AA1(4,31,31),AA2(4,31,31),AA3(4,31,31),AA4(4,31,31),
     1 KEYMAX
      DIMENSION VORT(600),ACONC(12),SAVE(22)
      DIMENSION U(31,31,2),W(31,31,2),SS(600,12)
      REAL MLL,LLIM
C
      NTRIAL=0
      KV=1
      IBED=0
      ILEAVE=999
      NSP1=NS+1
C
C     ....HERE TO SET INITIAL CONDITIONS....
      READ(5,25) RB,DREL,CU(1),CV(1),CW(1),ROO,BVOID,LLIM,SGAVE
      WRITE(6,125)RB,DREL,CU(1),CV(1),CW(1),ROO,BVOID,LLIM,SGAVE
  125    FORMAT(//10X,23HDISCHARGE PARAMETERS.../10X,30HINITIAL RADIUS O
     1F CLOUD, RB = ,G15.7/10X,40HINITIAL DEPTH OF CLOUD CENTROID, DREL
     2= ,G12.4/10X,35HINITIAL CLOUD VELOCITIES...CU(1) = ,G12.4,3X,
```

MODEL LISTING (15 of 85)

```
     3 8HCV(1) = ,G12.4,3X,8HCW(1) = ,G12.4//10X,18HBULK PARAMETERS.../
     4 10X,15HDENSITY, ROO = ,G15.7/10X,31HAGGREGATE VOIDS RATIO, BVOID
     5= ,G12.4,/10X,15HLIQUID LIMIT = ,G12.4,/10X,27HAVERAGE SPECIFIC GR
     6AVITY = ,G12.4)
      WRITE(6,135)NS
  135    FORMAT(//10X,10HTHERE ARE ,I2,34H SOLIDS.  PARAMETERS FOLLOW...
     1....//10X,90HDESCRIPTION  DENSITY(GM/CC)  CONCENTRATION(CUFT/CUFT)
     2  FALL VELOCITY(FT/SEC)    VOIDS RATIO  /)
      IF(KEYMAX.EQ.1)GO TO 310
      DO 300 KJ=1,NS
      READ(5,35)PARAM(KJ),ROAS(KJ),CS(KJ),VFALL(KJ),VOIDS(KJ),ICOHES(KJ)
      ROAS(KJ) = SGAVE
  300 CONTINUE
      GO TO 320
  310 CONTINUE
      DO 150 K=1,NS
      READ(5,35) PARAM(K),ROAS(K),CS(K),VFALL(K),VOIDS(K),ICOHES(K)
   35 FORMAT(A10,4E10.0,I5)
  150 CONTINUE
  320 CONTINUE
      DO 151 KK=1,NS
      WRITE(6,145) PARAM(KK),ROAS(KK),CS(KK),VFALL(KK),VOIDS(KK)
  145 FORMAT(11X,A10,2X,G12.4,9X,G12.4,15X,G12.4, 5X,G12.4)
  151 CONTINUE
C     READ INFO FOR DILUTION OF CHEMICAL TRACER
      READ(5,192)PARAM(NSP1),CINIT,CHACK(NSP1)
  192 FORMAT(A10,2E10.0)
C     CHANGE TRACER CONCENTRATION FROM MG/L TO MG/(CU FT)
      CBACK(NSP1)=CBACK(NSP1)*28.31602
      CINIT=CINIT*28.31602
      VFALL(NSP1)=0.
      FLUID=5HFLUID
C
C     CHECK CONSISTENCY OF PARAMETERS WITH NECESSARY MINIMUM FLUID DENSITY OF 1.
      CS(NSP1)=1.
      CIV=2.*PI*(RB*30.48)**3/3.
      CIVS=CIV
      CIM=ROO*CIV
      DO 170 K=1,NS
C     SET SOLIDS BACKGROUND TO BE ZERO
C     PROGRAM CAN NOT HANDLE NON-ZERO SOLIDS BACKGROUND
      CBACK(K)=0.0
      SV=CS(K)*CIVS
```

MODEL LISTING (16 of 85)

```
      SM=SV*ROAS(K)
      CS(NSP1)=CS(NSP1) - CS(K)
      CIV=CIV-SV
      CIM=CIM-SM
  170 CONTINUE
      FD=CIM/CIV
      WRITE(6,145) FLUID,FD,CS(NSP1),VFALL(NSP1)
      IF(FD .GE. .97) GO TO 190
      WRITE(6,185)
  185 FORMAT(//10X,44HFLUID DENSITY LESS THAN .97 GM/CC, CALL EXIT  )
      CALL EXIT
  190 CONTINUE
C     ....CONVERT UNITS FROM GM/CC TO SLUGS/CUFT....
      DO 200 I=1,NS
  200 ROAS(I)=ROAS(I)*1.94
      ROO=ROO*1.94
      PCM=100.*CS(NSP1)/(SGAVE*(1.-CS(NSP1)))
      MLL=PCM/LLIM
      IF(MLL.GT.2.9) GO TO 850
      IF(MLL.LT.1.43) GO TO 820
      ALFANO=-0.002185*(MLL**4)+0.0440555*(MLL**3)-.3119*(MLL**2)
     1+.91839*(MLL)-.67273
      GO TO 900
  820 IF(MLL.LE.1.22) GO TO 840
      ALFANO=.58286*(MLL-1.22)
       GO TO 900
  840  ALFANO=0.001
      GO TO 900
  850 ALFANO = 0.285+0.00493*(MLL-2.9)
  900 CONTINUE
      IF(KEYMAX.NE.1)GO TO 324
      WRITE(6,965) PCM,MLL,ALFANO
  324 CONTINUE
  965 FORMAT(//10X,27HPERCENT MOISTURE CONTENT = ,F10.4,1H,,F10.4,
     123H     TIMES LIQUID LIMIT,/10X,37HCALCULATED ENTRAINMENT COEFFICI
     2ENT = ,F10.6)
      CDNEW=0.7-0.5*TANH(3.2*(MLL-1.875))
       CMNEW=1.075-0.675*(TANH(3.2*(MLL-1.875)))
      IF (KEY1 .EQ. 2) GO TO 70
C
C     ....HERE TO USE TETRA TECH COEFFICIENTS....
      IF(KEYMAX.NE.1)GO TO 330
      WRITE(6,65)
  330 CONTINUE
   65 FORMAT(//////10X,37HUSE TETRA TECH SUGGESTED COEFFICIENTS )
      DINCR1=1.
      DINCR2=1.
      ALPHA0=ALFANO
      BETA=0.
      CM=CMNEW
      CD=CDNEW
      CDRAG=1.
      GAMA=0.25
      CFRIC=.01
      CD3=.1
      CD4=1.
      ALPHAC=.001
      FRICTN=.01
      F1=0.1
      ALAMDA=.005
      AKY0=.05
      GO TO 80
C
C     ....HERE TO READ IN COEFFICIENTS....
   70 WRITE(6,75)
   75 FORMAT(//////10X,24HUSF READ IN COEFFICIENTS )
      READ(5,25) DINCR1,DINCR2
      READ(5,25) ALPHA0,BETA,CM,CD
      IF(ALPHA0.LE.10.) GO TO 950
      ALPHA0=ALEANO
  950 CONTINUE
      IF(CD.LE.10.) GO TO 975
      CD=CDNEW
 975  CONTINUE
      IF (CM.LT.10.)  GO TO 985
      CM=CMNEW
  985 CONTINUE
      READ(5,25)GAMA,CDRAG,CFRIC,CD3,CD4,ALPHAC,FRICTN,F1
      READ(5,25) ALAMDA,AKY0
   25 FORMAT(8E10.0)
C
C     ....HERE TO WRITE COEFFICIENTS....
   80 IF(KEYMAX.NE.1) GO TO 350
      WRITE(6,85) DINCR1,DINCR2
   85 FORMAT(10X,6HDINCR1,F10.4,7H DINCR2,F10.4)
      WRITE(6,95) ALPHA0,BETA,CM,CD
```

MODEL LISTING (18 of 85)

```
   95 FORMAT(10X,6HALPHAO,F10.4,5H BETA,F10.4,3H CM,F10.4,3H CD,F10.4)
      WRITE(6,105)  GAMA,CDRAG,CFRIC,CD3,CD4,ALPHAC,FRICTN,F1
  105 FORMAT(10X,4HGAMA,5X,F5.2,3X,5HCDRAG,2X,F5.2,3X,5HCFRIC,1X,F5.3,
     1 2X,3HCD3,2X,F5.2,1X,3HCD4,1X,F5.2,1X,6HALPHAC,F10.4/10X,6HFRICTN,
     2  F10.4,1X,2HF1,F10.4 )
      WRITE(6,115)ALAMDA,AKYO
  115 FORMAT(10X,6HALAMDA,F10.4,1X,4HAKYO,F10.4/)
  350 CONTINUF
C     ....SAVE AMBIENT DENSITY AT Y(1)....
      ROAA=ROA(1)
      C1=(ROO-ROA(1))/ROA(1)
      E1=(ROA(NROA)-ROA(1))/(H*ROA(1))
      FF=CV(1)/SQRT(G*C1*RB)
      EE1=E1*RB/C1
C     TOTAL NUMBER OF EQUATIONS
      NE=9+NS
C     LONG TERM DIFFUSION PARAMETER
C    THE HORIZONTAL SCALE OF THE AMBIENT DIFFUSION PHENOMENON
     HAS BEEN SET AT 30 FT IN THIS MODEL SO AS TO BE INDEPENDENT
     OF GRID SPACING.  THE ORIGINAL VERSION  HAD A DX IN PLACE
C     OF THE 30. IN THE FOLLOWING STATEMENT
      DIF=ALAMDA*30.**1.333333*DTL/DX**2
      IF(DIF .GT. .2) DIF=.2
C     ....END OF INITIAL CONDITIONS....
C
C     ....SELECT TIME STER FOR INTEGRATIONS....
      IF(ROA(NROA) .NE. ROA(1)) GO TO 230
      IF(CV(1) .NE. 0.) GO TO 220
210   ACEL=32.21*(ROO-ROA(1))/(ROO+0.5*ROA(1))
      DT=(SQRT(2.*H/ACEL))/10.
      GO TO 250
  220 DT =.01*RB*FF*(1.+ALPHAO*H/RB)**2/(CV(1)*2.)
      GO TO 250
  230 IF(CV(1) .EQ. 0.) GO TO 210
C     CRITERION FROM CONDITION OF STRATIFICATION
      DT=.01*PI *FF/SQRT(EE1)
C     CRITERION FROM UNIFORM AMBIENT
      DT1=.01*RB*FF*(1.+ALPHAO*H/RB)**2/(CV(1)*2.)
      IF(DT-DT1) 250,240,240
  240 DT =DT1
C
C     ....INITIAL POSITION OF CLOUD CENTROID (W/R TO BARGE)
  250 E(1)=0.
```

```
      E(2)=DREL
      E(3)=0.
C     ....INITIAL MASS OF CLOUD....
      VOLUME=2.*PI *RB**3/3.
      E(4)=ROO*VOLUME
C     ....INITIAL MOMENTA....
      CMMASS=CM*E(4)
      E(5)=CMMASS*CU(1)
      E(6)=CMMASS*CV(1)
      E(7)=CMMASS*CW(1)
C     ....INITIAL BUOYANCY....
      E(8)=(ROA(1)-ROO)*VOLUME
C     ....INITIAL VORTICITY....
      E(9)=RB*CV(1)*FLOAT(KV)
C     ....SUBTRACT VOLUME OF VARIOUS SOLID COMPONENTS FROM TOTAL WASTE
C         VOLUME, VF, AND PLACE IN  E  ARRAY.  REMAINDER IN  VF  IS
C         VOLUME OF FLUID WASTE....
      VF=VOLUME
      DO 260 K=1,NS
      E(K+9)=CS(K)*VOLUME
  260 VF=VF-E(K+9)
      DO 270 I=1,NE
  270 SAVE(I)=E(I)
      ROSAV=ROO
      ALPHA=ALPHA0
      DINCR=DINCR1
      IF(KEYMAX.NE.1)GO TO 294
      WRITE(6,295)
  295 FORMAT(1H1,10X,18HCONVECTIVE DESCENT ///10X,34HCOMPUTATIONAL INDIC
     1ATORS FOLLOW...//10X,6HNTRIAL, 9X,2HDT, 7X,6HIPLUNG, 1X ,5HNUTRL,
     2 1X,5HISTEP  )
  294 CONTINUE
      IF(KEY4 .EQ. 1) DT=DT1U
C
C     ....HERE TO BEGIN A SOLUTION TRIAL....
  400 ROO=ROSAV
C     ....INCREMENT TRIAL NUMBER....
      NTRIAL=NTRIAL+1
C
C     ....INITIALIZE VARIABLES....
      T(1)=0.
      IY=1
      ISTEP=1
```

MODEL LISTING (20 of 85)

```
      NUTHL=0
      IPLUNG=0
      DO 410 I=1,NE
  410 E(I)=SAVE(I)
C
C     ....HERE TO BEGIN COMPUTATIONAL LOOP IN TIME....
C     ....STORE RESULTS FROM INITIAL CONDITIONS OR PREVIOUS COMPUTATION
C         IN APPROPRIATE ARRAYS....
  420 CX(ISTEP)=E(1)
      CY(ISTEP)=E(2)
      CZ(ISTEP)=E(3)
      VOLUME=(E(4)+E(8))/ROA(1)
      CMMASS=1./(CM*E(4))
      CU(ISTEP)=E(5)*CMMASS
      CV(ISTEP)=E(6)*CMMASS
      CW(ISTEP)=E(7)*CMMASS
C     WHEN VORTICITY GOES TO ZERO, IT IS SET TO ZERO
      IF(E(9) .LE. 0.) E(9)=0.
      VORT(ISTEP)=E(9)
C     BC=DIAMETER OF CLOUD
      AA(ISTEP)=(1.5*VOLUME/PI)**.333333
      BC(ISTEP)=2.*AA(ISTEP)
C     SS IS SOLID CONCENTRATION IN VOLUME RATIO
      DO 430 K=1,NS
  430 SS(ISTEP,K)=E(K+9)/VOLUME
C     FLUID CONCENTRATION
      FC(ISTEP)=VF/VOLUME
      VINIT=2.*PI*RR**3/3.
      CTRACE(ISTEP)=(CINIT*VINIT+(VOLUME-VINIT)*CBACK(NSP1))/VOLUME
      DR=CTRACE(ISTEP)/CINIT
      IF(DR .GT. DC(ITD)) GO TO 460
      TD(ITD)=T(ISTEP)
      ITD=ITD+1
  460 CONTINUE
C     NEW OVERALL DENSITY OF WASTE CLOUD
      ROO=E(4)/VOLUME
C     INTERPOLATE FOR AMBIENT DENSITY AT VERTICAL POSITION  E(2)
      ROAA=ROA(IY)+(E(2)-Y(IY))*(ROA(IY+1)-ROA(IY))/(Y(IY+1)-Y(IY))
C     CONVERT DENSITY DIFFERENCE BACK TO GM/CC AND STORE IN  DENDIF
      DENDIF(ISTEP)=(ROO-ROAA)*.51545
C     TEST FOR BOTTOM ENCOUNTER
      IF((CY(ISTEP)+3.*AA(ISTEP)/8.) .GE. H) IPLUNG=1
C     TEST FOR LOOP EXIT
```

MODEL LISTING (21 of 85)

```
            IF(IPLUNG .EQ. 1) GO TO 500
            IF(NUTRL .EQ. 1) GO TO 500
            IF(ISTEP .GE. 600) GO TO 500
      C     SOLVE EQUATION SET FOR NEXT TIME STEP
            CALL RUNGS(DERIVD,NE,U,W,DEPTH,NMAX,MMAX,NVL)
            ISTEP=ISTEP+1
            T(ISTEP)=T(ISTEP-1)+DT
            GO TO 420
      C     ....END OF LOOP IN TIME....
      C
        500 IF(KEYMAX.NE.1)GO TO 502
      C     PRINT OUT VARIABLES GUIDING JUST COMPLETED SOLUTION TRIAL
            WRITE(6,505) NTRIAL,DT,IPLUNG,NUTRL,ISTEP
        505 FORMAT( 9X,I5,G16.8,2X,3I6)
        502 CONTINUE
      C     ITF SAVES LAST TIME STEP OF DESCENT PHASE
            ITF=ISTEP
      C     TEST FOR PROPER NUMBER OF TIME STEPS IN CONVECTIVE CALCULATIONS
            IF(ISTEP .LT. 100 .OR. ISTEP .GT. 200)510,520
        510 DT=DT*FLOAT(ISTEP)*DINCR/150.
      C     IF FIFTH TRIAL COMPLETED, GO TO OUTPUT SECTION, IF NOT RETURN FOR
      C     NEXT TRIAL
            IF(NTRIAL .GE. 5) GO TO 520
            GO TO 400
      C     ....HERE FOR PRINTED AND/OR GRAPHICAL OUTPUT....
        520 IF(IPCN.EQ.0) GO TO 600
      C     ....HERE FOR PRINTOUT....
            WRITE(6,524)
        524 FORMAT(//10X,42HX AND Z ARE MEASURED W/R TO BARGE POSITION )
            WRITE(6,525)
        525 FORMAT(// 8X,4HTIME,5X,1HX,7X,1HY,7X,1HZ,6X,1HU,6X,1HV,5X,1HW,6X,
           1 7HDEN-DIF,3X,6HRADIUS,1X,5H DIA ,2X,5HVORT.,3X,12HFLUID CONC. ,
           2 10HSOLID-VOL.,2X,13HCONCENTRATION)
            LINC=ISTEP/60
            IF(LINC .LT. 1) LINC=1
            DO 560 J=1,ISTEP,LINC
            DO 530 K =1,NS
        530 ACONC(K )=2.*PI *AA(J)**3*SS(J,K )/3.
            WRITE(6,535) T(J),CX(J),CY(J),CZ(J),CU(J),CV(J),CW(J) ,DENDIF(J)
           1,AA(J),  BC(J),  VORT(J),FC(J),ACONC(1),SS(J,1)
        535 FORMAT( 4X,4F8.2,F6.2,F7.3,F6.2,E12.4,2F7.2,1X,F7.4,3E12.4)
            IF(NS .EQ. 1) GO TO 560
            DO 540 K=2,NS
```

```
  540 WRITE(6,545) ACONC(K ),SS(J,K)
  545 FORMAT(101X,2E12.4)
  560 CONTINUE
  600 IF(IGCN.EQ.0) GO TO 700
C     ....HERE FOR GRAPHING....
      ISTEP1=ISTEP+1
      T(ISTEP1)=2.*T(ISTEP)-T(ISTEP-1)
      CX(ISTEP1)=2.*CX(ISTEP)-CX(ISTEP-1)
      CZ(ISTEP1)=2.*CZ(ISTEP)-CZ(ISTEP-1)
      CY(ISTEP1)=0.
      AA(ISTEP1)=0.
      CTRACE(ISTEP1)=0.0
      CALL DRAW(T,T,T,T,CY,AA,CX,CZ,ISTEP1,1,4)
      IF(IGCN.EQ.1) GO TO 700
      DO 610 I=1,NS
  610 SS(ISTEP1,I)=0.
      NG=4
      IF(NS .LT. 4) NG=NS
      CALL DRAW(T,T,T,T,SS(1,1),SS(1,2),SS(1,3),SS(1,4),ISTEP1,3,NG)
      IF(NS .LE. 4) GO TO 700
      NG=4
      IF(NS .LT. 8) NG=NS-4
      CALL DRAW(T,T,T,T,SS(1,5),SS(1,6),SS(1,7),SS(1,8),ISTEP1,4,NG)
      IF(NS .LE. 8) GO TO 700
      NG=4
      IF(NS .LT. 12) NG=NS-8
      CALL DRAW(T,T,T,T,SS(1,9),SS(1,10),SS(1,11),SS(1,12),ISTEP1 ,7,NG)
  700 CONTINUE
C
C     ....SHIFT DATA TO PREPARE FOR COLLAPSE PHASE....
      DT1=DT
      DO 730 K=1,NS
      I=NS-K
  730 E(I+11)=E(I+10)
      E(9)=AA(ISTEP)
      A0=AA(ISTEP)
      IF(IPLUNG .EQ. 1) GO TO 720
      E(10)=0.
      RETURN
C     ....HERE IF CLOUD HAS HIT BOTTOM....
  720 E(10)=ROO*PI *E(9)**3*(2.666666*CV(ISTEP))/32.
      IBED=ISTEP
      RETURN
      END
```

MODEL LISTING (23 of 85)

```
SUBROUTINE  MAD                                   CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  16.53.32.        PAGE     1
      SUBROUTINE MAD(K,ETS,X,Z,U,W,C,THICK,TOP,DEPTH,ACCUM,CP,THICKP,
     1 TOPP,COUT,ICODE,TSIDE,TTHK,TTOP,TMASS,TX,TZ,NMAX,MMAX)
C     ROUTINE TO COMPUTE MOVEMENT AND DIFFUSION
      DIMENSION DEPTH(31,31)
      DIMENSION U(31,31,2),W(31,31,2)
      DIMENSION ICODE(31,31)
      DIMENSION C(31,31),THICK(31,31),TOP(31,31)
     1,ACCUM(31,31),CP(31,31)
     2, TOPP(31,31),COUT(31,31),TMASS(100),TSIDE(100),TTOP(100),
     3TX(100),TZ(100),TTHK(100),THICKP(31,31)
     4, X(31,31),Z(31,31)
      COMMON/GUIDE2/NIND,NLINE(150),MF(150),ML(150)
      COMMON/BAY/ DX,DTL,XBARGE,ZBARGE,DXH,DXR,AREA
      COMMON/DIMEN/ NS,NSP1,NVL,NSC
      COMMON/HA/AA1(4,31,31),AA2(4,31,31),AA3(4,31,31),AA4(4,31,31),
     1 KEYMAX
      COMMON/ID/IDTL
      COMMON/PIECES/ PARAM(13),ROAS(13),CS(13),VFALL(13),VOIDS(13),BVOID
     1,ICOHES(12),VFALLC(13),VFALSC(20,13),VFALLD(31,31,13)
      COMMON/POINT/MST,NST
      COMMON/CHECK/TOTAL
      COMMON/COR/ CM,CMAX
      COMMON/NC/ NTCLD
      COMMON/LOST/ GONE
      COMMON/P/ PRT
      COMMON/GPI/ G,PI,RB
      COMMON/FLEE/ ITD,TD(6),DC(6),CINIT,CBACK(13),CTRACE(600)
      COMMON/ENTRAN/ TEMAS(100),VOLSC(100)
      LOGICAL PRT
      Q=1.0E-06
      IF(NMAX .LE. 31 .AND. MMAX .LE. 31) GO TO 5
      WRITE(6,2)
    2 FORMAT(//,10X,64HNMAX OR MMAX GT 31 DIMENSION IN COMMON/PIECES/ MU
     1ST BE INCREASED)
      CALL EXIT
    5 CONTINUE
C
C     MOVE AND DIFFUSE SMALL CLOUDS, IF ANY
      IF(ABS(ETS-DTL) .LT. .0001) GO TO 10
      IF(NTCLD .GT. 0) CALL ACAD(K,C,THICK,TOP,ACCUM,DEPTH,U,W,TSIDE,
     1 TTHK,TTOP,TMASS,TX,TZ,NMAX,MMAX,ETS)
C
   10 CHKM=0.
```

MODEL LISTING (24 of 85)

```
      CMAX=0.
      I=0
      B=0.
      A=0.
      DO 20 M=1,MMAX
      DO 20 N=1,NMAX
      IF(THICK(N,M) .EQ. 0.) GO TO 18
      A=A+THICK(N,M)
      B=B+TOP(N,M)
      I=I+1
18    CONTINUE
      CMAX=AMAX1(CMAX,C(N,M))
   20 CHKM=CHKM+(C(N,M)-CBACK(K))*THICK(N,M)*AREA
      AVTH= A/FLOAT(I)
      AVTP=B/FLOAT(I)
      IF(CHKM .LT. 1.0E-06) GO TO 699
C-----------------------------------------------------------------------
C
C     BEGIN COMPUTATIONS OVER LARGE GRID
C
C-----------------------------------------------------------------------
      DO 100 N=1,NMAX
      DO 100 M=1,MMAX
      Z(N,M)=FLOAT(N)*DX
  100 X(N,M)=FLOAT(M)*DX
C
C     MOVE LOCATIONS OF POINTS WHICH TERMINATE IN THE BAY
      DO 200 NUM=1,NIND
      NST=NLINE(NUM)
      MFST=MF(NUM)
      MLST=ML(NUM)
      DO 200 MST=MFST,MLST
      IF( ICODE(NST,MST).GT.1) GO TO 200
C     NST AND MST ARE INDEX OF GRID POINT X(NST,MST) AND Z(NST,MST)
C     ARE COORDINATES OF LOCATION OF THIS PARTICLE AT START OF
C     CONVECTIVE STEP
      YY=AVTP+0.5*AVTH
      CALL TRNSPT  (Z(NST,MST),X(NST,MST),YY,U,W,DEPTH,ICODE,NMAX,MMAX
     1, NVL)
200   CONTINUE
C     CLEAR ARRAYS
      DO 320 M=1,MMAX
      DO 320 N=1,NMAX
```

MODEL LISTING (25 of 85)

```
      CP(N,M)=CBACK(K)
      THICKP(N,M)=0.
  320 TOPP(N,M)=0.
C
C     COMPUTE NEW CONCENTRATIONS FOR ALL POINTS IN BAY
      CM=0.
      DO 510 NUM=1,NIND
      NST=NLINE(NUM)
      MFST=MF(NUM)
      MLST=ML(NUM)
      DO 510 MST=MFST,MLST
      ZN=Z(NST,MST)*DXR
      XM=X(NST,MST)*DXR
      N=ZN+.0001
      M=XM+.0001
      EN=ZN-FLOAT(N)
      EM=XM-FLOAT(M)
      IF(EN .LT. .0001) EN=0.
      IF(EM .LT. .0001) EM=0.
      EN1=1.-EN
      EM1=1.-EM
      ISUM=0
      CALL AVESPT(N  ,M  ,C1,TH1,T1,ISUM,0,C,THICK,TOP,ICODE,NMAX,
     1     MMAX,DEPTH(N,M),K)
      CALL AVESPT(N+1,M  ,C2,TH2,T2,ISUM,1,C,THICK,TOP,ICODE,NMAX,
     1MMAX,DEPTH(N+1,M),K)
      CALL AVESPT(N+1,M+1,C3,TH3,T3,ISUM,2,C,THICK,TOP,ICODE,NMAX,
     1MMAX,DEPTH(N+1,M+1),K)
      CALL AVESPT(N  ,M+1,C4,TH4,T4,ISUM,3,C,THICK,TOP,ICODE,NMAX,
     1MMAX,DEPTH(N,M+1),K)
      CP(NST,MST)=CBACK(K)
      THICKP(NST,MST)=0.
      TOPP(NST,MST)=0.
      TN=AMAX1(TH1,TH2,TH3,TH4)
      IF(TN .EQ. 0.) GO TO 500
      C1=(C1*AREA*TH1+CBACK(K)*AREA*(TN-TH1))/(TN*AREA)
      C2=(C2*AREA*TH2+CBACK(K)*AREA*(TN-TH2))/(TN*AREA)
      C3=(C3*AREA*TH3+CBACK(K)*AREA*(TN-TH3))/(TN*AREA)
      C4=(C4*AREA*TH4+CBACK(K)*AREA*(TN-TH4))/(TN*AREA)
      THICKP(NST,MST)=TN
      GO TO (401,402,403,404,405,406,407,408,409,410,411,412,413,414,415
     1), ISUM
  401 CP(NST,MST)=C1
```

MODEL LISTING (26 of 85)

```
      TOPP(NST,MST)=T1
      GO TO 500
  402 CP(NST,MST)=C2
      TOPP(NST,MST)=T2
      GO TO 500
  404 CP(NST,MST)=C3
      TOPP(NST,MST)=T3
      GO TO 500
  408 CP(NST,MST)=C4
      TOPP(NST,MST)=T4
      GO TO 500
  403 CP(NST,MST)=(C2-C1)*EN+C1
      TOPP(NST,MST)=(T2-T1)*EN+T1
      IF(T1 .LT. Q .OR. T2 .LT. Q) TOP(NST,MST)=AMAX1(T1,T2)
      GO TO 500
  412 CP(NST,MST)=(C3-C4)*EN+C4
      TOPP(NST,MST)=(T3-T4)*EN+T4
      IF(T3 .LT. Q .OR. T4 .LT. Q)TOPP(NST,MST)=AMAX1(T3,T4)
      GO TO 500
  406 CP(NST,MST)=(C3-C2)*EM+C2
      TOPP(NST,MST)=(T3-T2)*EM+T2
      IF(T2 .LT. Q .OR. T3 .LT. Q)TOPP(NST,MST)=AMAX1(T2,T3)
      GO TO 500
  409 CP(NST,MST)=(C4-C1)*EM+C1
      TOPP(NST,MST)=(T4-T1)*EM+T1
      IF(T1 .LT. Q .OR. T4 .LT. Q)TOPP(NST,MST)=AMAX1(T1,T4)
      GO TO 500
  405 IF (EN*EM-.25) 401,421,404
  421 CP(NST,MST)=.5*(C1+C3)
      TOPP(NST,MST)=.5*(T1+T3)
      IF(T1 .LT. Q .OR. T3 .LT. Q)TOPP(NST,MST)=AMAX1(T1,T3)
      GO TO 500
  410 IF (EN-EM) 408,422,402
  422 CP(NST,MST)=.5*(C2+C4)
      TOPP(NST,MST)=.5*(T2+T4)
      IF(T2 .LT. Q .OR. T4 .LT. Q)TOPP(NST,MST)=AMAX1(T2,T4)
      GO TO 500
  407 AD=EN1+EM
      IF (AD .EQ. 0.0) GO TO 402
      CP(NST,MST)=(EN1*((C2-C1)*EN+C1)+EM*((C3-C2)*EM+C2))/AD
      TOP1=(T2-T1)*EN+T1
      IF(T1 .LT. Q .OR. T2 .LT. Q)TOP1=AMAX1(T1,T2)
      TOP2=(T3-T2)*EM+T2
```

MODEL LISTING (27 of 85)

```
      IF(T2 .LT. Q .OR. T3 .LT. Q)TOP2=AMAX1(T2,T3)
      TOPP(NST,MST)=(EN1*TOP1+EM*TOP2)/AD
      IF(TOP1 .LT. Q .OR. TOP2 .LT. Q)TOPP(NST,MST)=AMAX1(TOP1,TOP2)
      GO TO 500
  411 AD= EN+EM
      IF (AD .EQ. 0.0) GO TO 401
      CP(NST,MST)=(EN*((C2-C1)*EN+C1)+EM*((C4-C1)*EM+C1))/AD
      TOP1=(T2-T1)*EN+T1
      IF(T1 .LT. Q .OR. T2 .LT. Q) TOP1=AMAX1(T1,T2)
      TOP2=(T4-T1)*EM+T1
      IF(T1 .LT. Q .OR. T4 .LT. Q)TOP2=AMAX1(T1,T4)
      TOPP(NST,MST)=(EN*TOP1+EM*TOP2)/AD
      IF(TOP1 .LT. Q .OR. TOP2 .LT. Q)TOPP(NST,MST)=AMAX1(TOP1,TOP2)
      GO TO 500
  413 AD=EN+EM1
      IF (AD .EQ. 0.0) GO TO 408
      CP(NST,MST)=(EN*((C3-C4)*EN+C4)+EM1*((C4-C1)*EM+C1))/AD
      TOP1=(T3-T4)*EN+T4
      IF(T3 .LT. Q .OR. T4 .LT. Q)TOP1=AMAX1(T3,T4)
      TOP2=(T4-T1)*EM+T1
      IF(T1 .LT. Q .OR. T4 .LT. Q)TOP2=AMAX1(T1,T4)
      TOPP(NST,MST)=(EN*TOP1+EM1*TOP2)/AD
      IF(TOP1 .LT. Q .OR. TOP2 .LT. Q)TOPP(NST,MST)=AMAX1(TOP1,TOP2)
      GO TO 500
  414 AD=EN1+EM1
      IF (AD .EQ. 0.0) GO TO 404
      CP(NST,MST)=(EN1*((C3-C4)*EN+C4)+EM1*((C3-C2)*EM+C2))/AD
      TOP1=(T3-T4)*EN+T4
      IF(T3 .LT. Q .OR. T4 .LT. Q)TOP1=AMAX1(T3,T4)
      TOP2=(T3-T2)*EM+T2
      IF(T2 .LT. Q .OR. T3 .LT. Q)TOP2=AMAX1(T2,T3)
      TOPP(NST,MST)=(EN1*TOP1+EM1*TOP2)/AD
      IF(TOP1 .LT. Q .OR. TOP2 .LT. Q)TOPP(NST,MST)=AMAX1(TOP1,TOP2)
      GO TO 500
  415 CONE=(C2-C1)*EN+C1
      CTWO=(C3-C4)*EN+C4
      CP(NST,MST)=(CTWO-CONE)*EM+CONE
      TOP1=(T2-T1)*EN+T1
      IF(T1 .LT. Q .OR. T2 .LT. Q)TOP1=AMAX1(T1,T2)
      TOP2=(T3-T4)*EN+T4
      IF(T3 .LT. Q .OR. T4 .LT. Q)TOP2=AMAX1(T3,T4)
      TOPP(NST,MST)=(TOP2-TOP1)*EM+TOP1
      IF(EM .LT. .0001) GO TO 500
      IF(TOP1 .LT. Q .OR. TOP2 .LT. Q)TOPP(NST,MST)=AMAX1(TOP1,TOP2)
  500 IF((CP(NST,MST)-CBACK(K)) .GT. 1.E-20) GO TO 510
      CP(NST,MST)=CBACK(K)
      THICKP(NST,MST)=0.
      TOPP(NST,MST)=0.
  510 CONTINUE
      DO 2000 NUM=1,NIND
      NST=NLINE(NUM)
      MFST=MF(NUM)
      MLST=ML(NUM)
      DO 2000 MST=MFST,MLST
      DDTHK=TOPP(NST,MST)+THICKP(NST,MST)-DEPTH(NST,MST)
      IF(DDTHK .LE. 0.) GO TO 2000
      TOPP(NST,MST)=DEPTH(NST,MST)-THICKP(NST,MST)
 2000 CONTINUE
C
C     SHIFT ARRAYS AND ADD MASS LOST BY DIFFUSION LIMITING IN AVESPT
C     TO POINT OF MAXIMUM CONCENTRATION
      CMAX=0.
      C1=0.
      C2=0.
      NCOR=1
      MCOR=1
      DO 550 NUM=1,NIND
      NST=NLINE(NUM)
      MFST=MF(NUM)
      MLST=ML(NUM)
      DO 550 MST=MFST,MLST
      CMAX=AMAX1(CMAX,CP(NST,MST))
      IF(CMAX  .NE. CP(NST,MST)) GO TO 520
      NCOR=NST
      MCOR=MST
  520 CONTINUE
      IF(THICK(NST,MST) .EQ. 0.0 .AND. ICODE(NST,MST) .NE. 2)C1=C1+
     1CBACK(K)*AREA*DEPTH(NST,MST)
      IF(THICK(NST,MST) .NE. 0.0)C1=C1+C(NST,MST)*THICK(NST,MST)*
     1AREA+CBACK(K)*(DEPTH(NST,MST)-THICK(NST,MST))*AREA
      C(NST,MST)    =CP(NST,MST)
      VFALLD(NST,MST,K)=VFALL(K)
      THICK(NST,MST)=THICKP(NST,MST)
      IF(THICK(NST,MST) .EQ. 0.0 .AND. ICODE(NST,MST) .NE. 2)C2=C2+
     1CBACK(K)*AREA*DEPTH(NST,MST)
      IF(THICK(NST,MST) .NE. 0.0)C2=C2+C(NST,MST)*THICK(NST,MST)*
```

MODEL LISTING (29 of 85)

```
     1AREA+CBACK(K)*(DEPTH(NST,MST)-THICK(NST,MST))*AREA
C     DTOP ESTIMATES VARIATION OF CLOUD DEPTH DUE TO CONVECTION OVER
C     VARIABLE DEPTHS
      CALL DINT(X(NST,MST),Z(NST,MST),DD1,DEPTH,NMAX,MMAX)
      DTOP=(DD1-DEPTH(NST,MST))*TOP(NST,MST)/DD1
  550 TOP(NST,MST)=TOPP(NST,MST)-DTOP
      GONE=GONE+C1-C2
      IF((CMAX-CRACK(K)) .LT. 1.E-20) GO TO 555
C     ADD MASS LOST RY DIFFUSION LIMITING
      C(NCOR,MCOR)=C(NCOR,MCOR)+CM/(THICK(NCOR,MCOR)*AREA)
      GONE=GONE-CM
C
C     SETTLE SOLIDS....
  555 DO 680 NUM=1,NIND
      NST=NLINE(NUM)
      MFST=MF(NUM)
      MLST=ML(NUM)
      DO 680 MST=MFST,MLST
      IF(VFALLD(NST,MST,K) .EQ. 0.) GO TO 690
      IF(ICOHES(K) .EQ. 0) GO TO 610
      IF(C(NST,MST) .LE. 0.0000096) VFALLD(NST,MST,K)=0.0017
      IF(C(NST,MST) .GT. 0.0000096 .AND. C(NST,MST) .LE. 0.000115)
     1VFALLD(NST,MST,K)=(.00713*(C(NST,MST)*2600000.)**1.33333)/304.8
      IF(C(NST,MST) .GT. 0.000115) VFALLD(NST,MST,K)=0.047
  610 DIST=VFALLD(NST,MST,K)*DTL
      IF((C(NST,MST)-CBACK(K)) .EQ. 0. .OR. ICODE(NST,MST) .GT. 1) GO
     1TO 680
  611 XS=DEPTH(NST,MST)-TOP(NST,MST)-THICK(NST,MST)
      IF(XS .GE. DIST) GO TO 640
      IF(XS .GE. 0.) GO TO 612
      IF(ABS(XS) .GT. THICK(NST,MST)) GO TO 630
      FALOUT=ABS(XS)*C(NST,MST)*AREA
      ACCUM(NST,MST)=ACCUM(NST,MST)+FALOUT
      THICK(NST,MST)=THICK(NST,MST)-ABS(XS)
      GO TO 611
  612 IF(THICK(NST,MST) .LT. (DIST-XS)) GO TO 630
      FALOUT =(DIST-XS)*AREA *C(NST,MST)
      ACCUM(NST,MST)=ACCUM(NST,MST)+FALOUT
      THICK(NST,MST)=THICK(NST,MST)-(DIST-XS)
      TOP(NST,MST)=TOP(NST,MST)+DIST
      GO TO 680
  630 CONTINUE
      ACCUM(NST,MST)=ACCUM(NST,MST)+THICK(NST,MST)*AREA *C(NST,MST)
      C(NST,MST)=CBACK(K)
      TOP(NST,MST)=DEPTH(NST,MST)
      THICK(NST,MST)=0.
      GO TO 680
  640 CONTINUE
      TOP(NST,MST)=TOP(NST,MST)+DIST
  680 CONTINUE
  690 CONTINUE
      IF((TOP(NST,MST)+THICK(NST,MST)) .GT. DEPTH(NST,MST))
     1TOP(NST,MST)=DEPTH(NST,MST)-THICK(NST,MST)
C
C     VERTICAL DIFFUSION...
      DO 600 IDTL3 = 1,10
  560 DO 600 NUM=1,NIND
      NST=NLINE(NUM)
      MFST=MF(NUM)
      MLST=ML(NUM)
      DO 600 MST=MFST,MLST
      IF((C(NST,MST)-CBACK(K)) .LT. 1.E-20) GO TO 600
      IF(THICK(NST,MST) .EQ. 0.) GO TO 600
      OTHICK=THICK(NST,MST)
      OTOP=TOP(NST,MST)
      CALL VDIFCO(NST,MST,OTOP,DCO,U,W,DEPTH,NMAX,MMAX,NVL)
      DINK=2.0*SQRT(DCO*DTL/10.0)
      IF(TOP(NST,MST) .GT. 0.) TOP(NST,MST)=TOP(NST,MST)-DINK
      IF(TOP(NST,MST) .LT. 0.) TOP(NST,MST)=0.
C
      OBOT=OTOP+THICK(NST,MST)
      IF(OBOT .GT. DEPTH(NST,MST)) OBOT=DEPTH(NST,MST)
      CALL VDIFCO(NST,MST,OBOT,DCO,U,W,DEPTH,NMAX,MMAX,NVL)
      DONK=2.0*SQRT(DCO*DTL/10.0)
      OBOT=OBOT+DONK
      IF(OBOT .GT. DEPTH(NST,MST)) OBOT=DEPTH(NST,MST)
      THICK(NST,MST)=OBOT-TOP(NST,MST)
      C(NST,MST)=(C(NST,MST)*OTHICK*AREA+CBACK(K)*AREA*(THICK(NST,MST)-
     1OTHICK))/(AREA*THICK(NST,MST))
  600 CONTINUE
C
C     CHECK FLUID DILUTION
      IF(K .NE. NSP1) GO TO 698
      CMAX2=0.
      DO 696 NUM=1,NIND
      NST=NLINE(NUM)
      MFST=MF(NUM)
      MLST=ML(NUM)
      DO 696 MST=MFST,MLST
      IF(C(NST,MST) .LT. CMAX2) GO TO 696
      CMAX2=C(NST,MST)
      NSTSV=NST
      MSTSV=MST
  696 CONTINUE
      IF((CMAX2-CBACK(K)) .LE. 1.E-30) GO TO 698
      DR=CMAX2/CINIT
      IF(DR .GT. DC(ITD)) GO TO 698
      TD(ITD)=ETS
      ITD=ITD+1
  698 CONTINUE
C     CHECK FOR MASS CONSERVATION
  699 TNORM=0.
      TACCUM=0.
      GMASS=0.0
      DO 704 NUM=1,NIND
      NST=NLINE(NUM)
      MFST=MF(NUM)
      MLST=ML(NUM)
      DO 704 MST=MFST,MLST
      TACCUM=TACCUM+ACCUM(NST,MST)
      GMASS=GMASS+CBACK(K)*DEPTH(NST,MST)*AREA
      IF(THICK(NST,MST) .EQ. 0.0 .AND. ICODE(NST,MST) .NE. 2) TNORM=
     1TNORM+CBACK(K)*AREA*DEPTH(NST,MST)
  704 IF(THICK(NST,MST) .NE. 0.0)TNORM=TNORM+C(NST,MST)*THICK(NST,MST)
     1*AREA+CBACK(K)*(DEPTH(NST,MST)-THICK(NST,MST))*AREA
      IF(ETS .GT; DTL)TNORM=TNORM-GMASS+(2.*PI*RB**3/3.)*CBACK(K)
      IF(ETS .EQ. DTL) TNORM=TNORM-GMASS
      TRANS=0.
      IF(NTCLD  .LT. 1) GO TO 710
      DO 708 I=1,NTCLD
  708 TRANS=TRANS+TMASS(I)-TEMAS(I)
  710 TOTAL=TNORM+TRANS
      IF(KEYMAX.NE.1)GO TO 928
      WRITE(6,712) PARAM(K),ETS,TOTAL,TNORM,TRANS,TACCUM
  928 CONTINUE
  712 FORMAT(/////5X,11HSUMMARY OF ,A10,21H DISTRIBUTIONS AFTER ,
     1 F10.2,6H SEC. //5X,34HTOTAL SUSPENDED MATERIAL (CUFT) = ,G14.5
     2/5X,46HSUSPENDED MATERIAL IN LONG TERM GRID (CUFT) = ,G14.5
     3/5X,44HSUSPENDED MATERIAL IN SMALL CLOUDS (CUFT) = ,G14.5
```

MODEL LISTING (32 of 85)

```
     4/5X,42HTOTAL MATERIAL SETTLED TO BOTTOM (CUFT) = ,G14.5
     5//5X,55HOUTPUT SUPPRESSED IN LOCATIONS WITH NO MATERIAL PRESENT )
      IF(KEYMAX.NE.1)GO TO 910
      IF(ABS(GONE) .GT. 1.) WRITE(6,715) GONE
  910 CONTINUE
  715 FORMAT(/10X,G12.5,72H CUFT OF MATERIAL (CUMULATIVE) LOST BY PASSIN
     1G THROUGH GRID BOUNDARIES    )
      IF(.NOT.PRT) RETURN
      IDTL = IDTL + 1
C
C
C     PRINT RESULTS IF REQUESTED BY INPUT DATA
      IF(TNORM .LT. 1.0E-06) GO TO 725                                  C
  719 CONTINUE
      DO 720 M=1,MMAX
      DO 720 N=1,NMAX
  900 FORMAT(//,7HVFALLD=,F14.6)
      COUT(N,M)=C(N,M)-CBACK(K)
      AA1(IDTL,N,M) = AA1(IDTL,N,M) + C(N,M)-CBACK(K)
  720 IF(K .EQ. NSP1) COUT(N,M)=COUT(N,M)/28.31602
      IF(KEYMAX.NE.1)GO TO 722
      CALL PRINTC(COUT,NMAX,MMAX ,PARAM(K),ETS,1,ICODE)
  722 CONTINUE
      DO 770 M=1,MMAX
      DO 770 N=1,NMAX
      AA3M = AMIN1(AA3(IDTL,N,M),TOP(N,M))
      IF(AA3(IDTL,N,M).LT.0.00001)AA3M=TOP(N,M)
      AA3(IDTL,N,M) = AA3M
  770 COUT(N,M)=TOP(N,M)
      IF(KEYMAX.NE.1)GO TO 772
      CALL PRINTC(COUT,NMAX,MMAX,PARAM(K),ETS,3,ICODE)
  772 CONTINUE
      DO 780 M=1,MMAX
      DO 780 N=1,NMAX
      AA4M = AMAX1(AA4(IDTL,N,M),THICK(N,M))
      AA4(IDTL,N,M) = AA4M
  780 COUT(N,M)=THICK(N,M)
      IF(KEYMAX.NE.1)GO TO 782
      CALL PRINTC(COUT,NMAX,MMAX,PARAM(K),ETS,4,ICODE)
  782 CONTINUE
  725 IF(K .EQ. NSP1) GO TO 760
      IF(TOTAL.GT.1.0E-06)GO TO 1002
      DO 1003 IDTL=IDTL,4
```

MODEL LISTING (33 of 85)

```
      DO 1003 M=1,MMAX
      DO 1003 N=1,NMAX
 1003 AA2(IDTL,N,M)=AA2(IDTL,N,M)+ACCUM(N,M)
      GO TO 732
 1002 DO 730 M=1,MMAX
      DO 730 N=1,NMAX
      AA2(IDTL,N,M) = AA2(IDTL,N,M)  + ACCUM(N,M)
  730 COUT(N,M)=ACCUM(N,M)
      IF(KEYMAX.NE.1) GO TO 732
      CALL PRINTC(COUT,NMAX,MMAX,PARAM(K), ETS,2,ICODE)
  732 CONTINUE
  760 CONTINUE
      IF(NTCLD .EQ. 0) RETURN
      WRITE(6,805) ETS,PARAM(K)
  980 CONTINUE
  805 FORMAT(18H1  SMALL CLOUDS AT ,F10.2,27H SECONDS ELAPSED TIME  FOR
     X,A10,//
     1 2X,1HN,7X,1HX,13X,1HZ,11X,5HTMASS,9X,5HTSIDE,10X,4HTTHK,9X,4HTTOP
     2 )
      WRITE(6,815)(N,TX(N),TZ(N),TMASS(N),TSIDE(N),TTHK(N),TTOP(N),
     1VFALSC(N,K),N=1,NTCLD)
  990 CONTINUE
  815 FORMAT(1X,I2,1X,7G14.4)
  890 RETURN
      END
```

MODEL LISTING (34 of 85)

```
SUBROUTINE  TRNSPT                                CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  16.53.32.       PAGE       1
                  SUBROUTINE TRNSPT  (ZZ,XX,YY,U,W,DEPTH,ICODE,NMAX,MMAX,NVL)
                  DIMENSION DEPTH(31,31)
                  DIMENSION ICODE(31,31)
                  DIMENSION U(31,31,2),W(31,31,2)
                  COMMON/BAY/ DX,DTL,XBARGE,ZBARGE,DXH,DXR,AREA
                  COMMON/POINT/ MST,NST
                  N=ZZ*DXR+.5
                  M=XX*DXR+.5
            C     DETERMINE VELOCITIES
                  CALL VEL(XX,YY,ZZ,UA,WA,U,W,DEPTH,NMAX,MMAX)
                  XX=XX-UA*DTL
                  ZZ=ZZ-WA*DTL
                  NE=ZZ*DXR+.5
                  ME=XX*DXR+.5
            C     CHECK THAT MARKER PARTICLE DOES NOT COME FROM OUT OF BOUNDS
                  IF(NE .GT. 0) GO TO 1
                  NE=1
                  ZZ=FLOAT(NE)*DX
                1 IF(NE .LE. NMAX) GO TO 2
                  NE=NMAX
                  ZZ=FLOAT(NE)*DX
                2 IF(ME .GT. 0) GO TO 3
                  ME=1
                  XX=FLOAT(ME)*DX
                3 IF(ME .LE. MMAX) GO TO 4
                  ME=MMAX
                  XX=FLOAT(ME)*DX
                4 CONTINUE
                  ITMP=ICODE(NE,MF)
                  IF (ITMP .NE. 2) GO TO 50
                  ZZ=FLOAT(N)*DX
                  XX=FLOAT(M)*DX
               50 RETURN
                  END
```

MODEL LISTING (35 of 85)

```
SUBROUTINE  AVE5PT                               CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  16.53.32.       PAGE      1

      SUBROUTINE AVE5PT(N,M,CONC,THK,XTOP,ISUM,J,C,THICK,TOP,ICODE,NMAX,
     1     MMAX,DCENT,K)
C     ROUTINE TO AVERAGE CONCENTRATIONS IN A 5 POINT STAR PATTERN
C     DIFFUSION LIMITED FROM THOSE POINTS WITH CONCENTRATIONS LESS
C     THAN EPSLN.      MASS LOST IN CONSEQUENCE IS ADDED IN ROUTINE
C     MAD TO POINT OF MAXIMUM CONCENTRATION.
      DIMENSION ICODE(31,31)
      DIMENSION C(31,31),THICK(31,31),TOP(31,31)
      COMMON/BAY/ DX,DTL,XBARGE,ZBARGE,DXH,DXR,AREA
      COMMON/COR/ CM,CMAX
      COMMON/LTCOF/ ALAMDA,DIF,AKYO
      COMMON/FLEE/ ITD,TD(6),DC(6),CINIT,CBACK(13),CTRACE(600)
      EPSLN=2.0E-05*(CMAX-CBACK(K))
      COCEAN=0.
      IF(N.LT.1)N=1
      IF(M.LT.1)M=1
      IF(N.GT.NMAX)N=NMAX
      IF(M.GT.MMAX)M=MMAX
      IF(ICODE(N,M)-2)1,2,3
    2 CONC=0.0
      XTOP=0.
      THK=0.
      RETURN
   3  CONC=CBACK(K)
      XTOP=0.
      THK=0.
      GO TO 200
C
    1 C1=C(N,M)
      T1=TOP(N,M)
      TH1=THICK(N,M)
      IF((C1-CBACK(K)).GT. EPSLN) GO TO 7
      CM=CM+(C1-CBACK(K))*TH1*AREA
      C1=CBACK(K)
      C(N,M)=CBACK(K)
      TOP(N,M)=0.
      THICK(N,M)=0.
    7 CONTINUE
C
      C2=C(N-1,M)
      T2=TOP(N-1,M)
      TH2=THICK(N-1,M)
      IF((C2-CBACK(K)) .GT. EPSLN) GO TO 9
      CM=CM+(C2-CBACK(K))*AREA*THICK(N-1,M)
      C2=CBACK(K)
      C(N-1,M)=CBACK(K)
      TOP(N-1,M)=0.
      THICK(N-1,M)=0.
    9 CONTINUE
      IF(ICODE(N-1,M) .NE. 2) GO TO 10
      C2=C1
      T2=T1
      TH2=TH1
   10 IF(ICODE(N-1,M) .NE. 3) GO TO 20
      C2=CBACK(K)
      T2=T1
      TH2=TH1
C
   20 C3=C(N+1,M)
      T3=TOP(N+1,M)
      TH3=THICK(N+1,M)
      IF((C3-CBACK(K)) .GT. EPSLN) GO TO 27
      CM=CM+(C3-CBACK(K))*THICK(N+1,M)*AREA
      C3=CBACK(K)
      C(N+1,M)=CBACK(K)
      TOP(N+1,M)=0.
      THICK(N+1,M)=0.
   27 CONTINUE
      IF(ICODE(N+1,M) .NE. 2) GO TO 30
      C3=C1
      T3=T1
      TH3=TH1
   30 IF(ICODE(N+1,M) .NE. 3) GO TO 40
      C3=CBACK(K)
      T3=T1
      TH3=TH1
C
   40 C4=C(N,M+1)
      T4=TOP(N,M+1)
      TH4=THICK(N,M+1)
      IF((C4-CBACK(K)) .GT. EPSLN) GO TO 47
      CM=CM+(C4-CBACK(K))*THICK(N,M+1)*AREA
      C4=CBACK(K)
      C(N,M+1)=CBACK(K)
      TOP(N,M+1)=0.
      THICK(N,M+1)=0.
   47 CONTINUE
      IF(ICODE(N,M+1) .NE. 2) GO TO 50
      C4=C1
      T4=T1
      TH4=TH1
   50 IF(ICODE(N,M+1) .NE. 3) GO TO 60
      C4=CBACK(K)
      T4=T1
      TH4=TH1
C
   60 C5=C(N,M-1)
      T5=TOP(N,M-1)
      TH5=THICK(N,M-1)
      IF((C5-CBACK(K)) .GT. EPSLN) GO TO 67
      CM=CM+(C5-CBACK(K))*THICK(N,M-1)*AREA
      C5=CBACK(K)
      C(N,M-1)=CBACK(K)
      TOP(N,M-1)=0.
      THICK(N,M-1)=0.
   67 CONTINUE
      IF(ICODE(N,M-1) .NE. 2) GO TO 70
      C5=C1
      T5=T1
      TH5=TH1
   70 IF(ICODE(N,M-1) .NE. 3) GO TO 80
      C5=CBACK(K)
      T5=T1
      TH5=TH1
   80 CONTINUE
C
C     SET THICKNESS AND TOP OF NEW ELEMENT TO AVERAGE OF CONTRIBUTING ELEMENTS
      INUM=0
      TOPSUM=0.
      IF(TH1.EQ. 0.) GO TO 83
      INUM=INUM+1
      TOPSUM=TOPSUM+T1
   83 IF(TH2.EQ. 0.) GO TO 84
      INUM=INUM+1
      TOPSUM=TOPSUM+T2
   84 IF(TH3.EQ. 0.) GO TO 86
      INUM=INUM+1
      TOPSUM=TOPSUM+T3
   86 IF(TH4.EQ. 0.) GO TO 88
```

MODEL LISTING (38 of 85)

```
SUBROUTINE  AVESPT                                       CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  16.53.32.     PAGE     4
                  INUM=INUM+1
                  TOPSUM=TOPSUM+T4
               88 IF(TH5.EQ. 0.) GO TO 92
                  INUM=INUM+1
                  TOPSUM=TOPSUM+T5
               92 IF(INUM .EQ. 0) GO TO 190
                  THK=AMAX1(TH1,TH2,TH3,TH4,TH5)
                  XTOP=TOPSUM/FLOAT(INUM)
                  IF(XTOP+THK .GT. DCENT) XTOP=DCENT-THK
C
C                 5 POINT AVERAGING FOLLOWS
                  CEF1=(C1*TH1*AREA+CBACK(K)*AREA*(THK-TH1))/(AREA*THK)
                  CEF2=(C2*TH2*AREA+CBACK(K)*AREA*(THK-TH2))/(AREA*THK)
                  CEF3=(C3*TH3*AREA+CBACK(K)*AREA*(THK-TH3))/(AREA*THK)
                  CEF4=(C4*TH4*AREA+CBACK(K)*AREA*(THK-TH4))/(AREA*THK)
                  CEF5=(C5*TH5*AREA+CBACK(K)*AREA*(THK-TH5))/(AREA*THK)
                  CONC=CEF1-DIF*(4.*CEF1-(CEF2+CEF3+CEF4+CEF5))
                  GO TO 200
              190 CONTINUE
                   CONC=CBACK(K)
                  THK=0.
                  XTOP=0.
              200 ISUM=ISUM+ 2**J
                  RETURN
                  END


SUBROUTINE  PFIX                                         CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.06.04.     PAGE     1
                  SUBROUTINE PFIX(P,IB,LIA,SYM)
C                 ROUTINE TO PLACE ALPHAMERIC CHARACTER INTO PROPER PRINT
C                 POSITION IN ARRAY P
                  DIMENSION BUF(5),P(2400)
                  IB5=IB/5
                  LIB=LIA+IB5+1
                  DECODE(5,1000,P(LIB)) BUF                                          NON-ANSI
             1000 FORMAT(5A1)
                  IRES=IB-5*IB5+1
                  BUF(IRES)=SYM
                  ENCODE(5,1000,P(LIB)) BUF                                          NON-ANSI
                  RETURN
                  END
```

MODEL LISTING (39 of 85)

```
      SUBROUTINE PRINTC(OUT,NMX,MMX,PARAM,ET,LBL,ICODE)
      DIMENSION OUT(31,31)
      DIMENSION ICODE(31,31)
      DIMENSION IPR(128),NUM(10)
      DATA IB,LND,ISEA,IPLUS,IDOT /1H ,1HL,1HO,1H+,1H./
      DATA NUM(1),NUM(2),NUM(3),NUM(4),NUM(5),NUM(6),NUM(7),NUM(8),
     1 NUM(9),NUM(10) /1H0,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1H9/
C
C     SCALE ARRAY FOR OPTIMUM PRINTOUT
      NMAX = NMX
      PMAX=0.
      DO 50 M=1,MMX
      DO 50 N=1,NMX
   50 PMAX=AMAX1(PMAX,OUT(N,M))
      P10=1.
      IP10=1
      IF(PMAX .GT. 0.) IP10=ALOG10(PMAX)
      IF(IP10 .GE. 3) P10=10.**(IP10-2)
      IF(IP10 .LT.  0) P10=10.**(IP10-1)
      DO 60 M=1,MMX
      DO 60 N=1,NMX
   60 OUT(N,M)=OUT(N,M)/P10
C
      GO TO (150,200,250,300,350,400,450),LBL
  150 WRITE(6,155) PARAM,ET
  155 FORMAT(19H1CONCENTRATIONS OF ,A10,29H (VOLUME RATIO) IN THE CLOUD
     1, F10.2,19H SECONDS AFTER DUMP )
      GO TO 500
  200 WRITE(6,215) PARAM,ET
  215 FORMAT(24H1BOTTOM ACCUMULATION OF ,A10,20H (CUFT/GRID SQUARE) ,
     1, F10.2,19H SECONDS AFTER DUMP )
      GO TO 500
  250 WRITE(6,255)PARAM,ET
  255 FORMAT(20H1POSITION OF TOP OF ,A10,28H CLOUD (FEET BELOW SURFACE)
     1, F10.2,19H SECONDS AFTER DUMP )
      GO TO 500
  300 WRITE(6,305) PARAM,ET
  305 FORMAT(14H1THICKNESS OF ,A10,14H CLOUD (FEET)
     1, F10.2,19H SECONDS AFTER DUMP )
      GO TO 500
  350 WRITE(6,355) PARAM,ET
  355 FORMAT(19H1THICKNESS (FT) OF ,A10,24H ACCUMULATED ON BOTTOM,
     1, F10.2,19H SECONDS AFTER DUMP )
```

MODEL LISTING (40 of 85)

```
      GO TO 500
  400 WRITE(6,405) ET
  405 FORMAT(59H1TOTAL ACCUMULATED SOLID VOLUME ON BOTTOM (CUFT/GRID SQR
     1), ,F10.2,19H SECONDS AFTER DUMP  )
      GO TO 500
  450 WRITE(6,455)ET
  455 FORMAT(48H1TOTAL THICKNESS (FT) OF NEW MATERIAL ON BOTTOM, ,
     1F10.2,19H SECONDS AFTER DUMP  )
  500 CONTINUE
      WRITE(6,505) P10
  505 FORMAT(33H ...MULTIPLY DISPLAYED VALUES BY ,G11.4,5X,60H(LEGEND...
     1 + = .LT. .01   . = .LT. .0001   0 = .LT. .000001))
C
C     SET UP PAGE DIVISIONS FOR PRINTING OF ARRAY
      NCP=NMX/32+1
      IF((NCP-1)*32 .EQ. NMAX) NCP=NCP-1
      IN2=0
      DO 1000 IP=1,NCP
      IN1=IN2+1
      IN2=IN2+32
      IF(NMX .LT. IN2)IN2=NMX
      WRITE(6,605) (N,N=IN1,IN2)
  605 FORMAT(2X,5HM N= ,I2,31I4)
C
      DO 100 M=1,MMX
      DO 10 I=1,128
   10 IPR(I)=IB
      DO 1 N=IN1,IN2
      J=4*N
      L=OUT(N,M)+.5
      IF(ICODE(N,M) .EQ. 2) GO TO 2
      IF(ICODE(N,M) .EQ. 3) GO TO 7
      IF (L.GE. 1000) GO TO 6
      IF (L .GE. 100) GO TO 3
      IF (L .GE. 10) GO TO 4
      IF(OUT(N,M) .GE. 1.) GO TO 30
      IF(OUT(N,M) .LT. 1.0E-06) GO TO 25
      IF(OUT(N,M) .LT. .0001) GO TO 18
      IF(OUT(N,M) .LT. .01) GO TO 8
      IF(OUT(N,M) .LT. .1) GO TO 20
      IPR(J-2)=IDOT
      N1=10.*OUT(N,M)
      IPR(J-1)=NUM(N1+1)
```

MODEL LISTING (41 of 85)

```
      N2=100.*OUT(N,M)-10.*FLOAT(N1)
      IPR(J)=NUM(N2+1)
      GO TO 1
   30 LF=OUT(N,M)
      LL=10.*(OUT(N,M)-FLOAT(LF))
      IPR(J)=NUM(LL+1)


      IPR(J-1)=IDOT
      IPR(J-2)=NUM(LF+1)
      GO TO 1
   25 IPR(J)=NUM(L+1)
      GO TO 1
   20 IPR(J-2)=IDOT
      IPR(J-1)=NUM(1)
      N2=100.*OUT(N,M)
      IPR(J)=NUM(N2+1)
      GO TO 1
    2 IPR(J)=LND
      IPR(J-1)=LND
      IPR(J-2)=LND
      IPR(J-3)=LND
      GO TO 1
    7 IPR(J)=ISEA
      IPR(J-1)=ISEA
      IPR(J-2)=ISEA
      IPR(J-3)=ISEA
      GO TO 1
    6 N1=L/1000
      IPR(J-3)=NUM(N1+1)
      N1=L-1000*N1
      N2=N1/100
      IPR(J-2)=NUM(N2+1)
      N2=N1-100*N2
      N3=N2/10
      IPR(J-1)=NUM(N3+1)
      N1=N2-10*N3
      IPR(J)=NUM(N1+1)
      GO TO 1
    3 N1=L/100
      IPR(J-2)=NUM(N1+1)
      N1=L-100*N1
      N2=N1/10
```

```
SUBROUTINE  PRINTC                                    CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  16.53.32.      PAGE      4
              IPR(J-1)=NUM(N2+1)
              N1=N1-10*N2
              IPR(J)=NUM(N1+1)
              GO TO 1
            4 N1=L/10
              IPR(J-1)=NUM(N1+1)
              N1=L-10*N1
              IPR(J)=NUM(N1+1)
              GO TO 1
            8 IPR(J)=IPLUS
              GO TO 1
           18 IPR(J)=IDOT
            1 CONTINUE
              WRITE(6,205) M,IPR
          205 FORMAT (/ 1X ,I3,1X,128A1)
          100 CONTINUE
              IF(IP .LT. NCP) WRITE(6,705)
          705 FORMAT(1H1//)
         1000 CONTINUE
              RETURN
              END

SUBROUTINE  DINT                                      CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  16.53.32.      PAGE      1

              SUBROUTINE DINT(XD,ZD,DEP,DEPTH,NMAX,MMAX)
        C     ROUTINE TO INTERPOLATE ON DEPTH GRID FOR DEPTH AT AN ARBITRARY
        C     POINT IN THE ESTUARY
        C     GIVEN POSITION (XD,ZD) IN ESTUARY COORDINATES, RETURNS DEPTH (DEP)
              DIMENSION DEPTH(31,31)
              COMMON/BAY/ DX,DTL,XBARGE,ZBARGE,DXH,DXR,AREA
              ZN=ZD*DXR
              XM=XD*DXR
              N=ZN+.0001
              M=XM+.0001
              EN=ZN-FLOAT(N)
              EM=XM-FLOAT(M)
              IF(EN .LT. .0001) EN=0.
              IF(EM .LT. .0001) EM=0.
              D1=DEPTH(N,M)+EN*(DEPTH(N+1,M)-DEPTH(N,M))
              D2=DEPTH(N,M+1)+EN*(DEPTH(N+1,M+1)-DEPTH(N,M+1))
              DEP=D1+EM*(D2-D1)
              RETURN
              END
```

MODEL LISTING (43 of 85)

```
      SUBROUTINE VDIFCO(N,M,YY,AKY,U,W,DEPTH,NMAX,MMAX,NVL)
C     ROUTINE TO COMPUTE VERTICAL DIFFUSION COEFFICIENTS
      DIMENSION DEPTH(31,31)
      DIMENSION U(31,31,2),W(31,31,2)
      COMMON/BAY/ DX,DTL,XBARGE,ZBARGE,DXH,DXR,AREA
      COMMON/GPI/ G,PI
      COMMON/LTCOF/ ALAMDA,DIF,AKYO
      COMMON/AMB/  NROA,IY,Y(10),ROA(10),H
C     DETERMINE DENSITY AND VELOCITY GRADIENTS
      IF(N.GT.NMAX) N=NMAX
      IF(M.GT.MMAX) M=MMAX
      IY=0
   10 IY=IY+1
      IF(YY .GE. Y(IY) .AND. YY .LE. Y(IY+1)) GO TO 20
      GO TO 10
   20 RHO=ROA(IY)+(ROA(IY+1)-ROA(IY))*(YY-Y(IY))/(Y(IY+1)-Y(IY))
      DENGRA=(ROA(IY+1)-ROA(IY))/(Y(IY+1)-Y(IY))
      Y1=YY+1.
      Y2=YY-1.
      XX=FLOAT(M)*DX
      ZZ=FLOAT(N)*DX
      CALL VEL(XX,Y1,ZZ,UA1,WA1,U,W,DEPTH,NMAX,MMAX)
      CALL VEL(XX,Y2,ZZ,UA2,WA2,U,W,DEPTH,NMAX,MMAX)
      VELGRA=SQRT((UA2-UA1)**2 + (WA2-WA1)**2)/2.
      IF(VELGRA .NE. 0.) GO TO 40
C     USE PRITCHARD DEFINITION OF RICHARDSON NO.
      CALL VEL(XX,0.,ZZ,UA1,WA1,U,W,DEPTH,NMAX,MMAX)
      VELGRA=0.7*SQRT(UA1**2 + WA1**2)/DEPTH(N,M)
C     DETERMINE RICHARDSON NO.
      IF(VELGRA .NE. 0.) GO TO 40
      AKY=0.
      IF(DENGRA.LT.1.0E-20) AKY=AKYO
      RETURN
   40 RI=G*DENGRA/(RHO*VELGRA**2)
C     CHECK BOUNDS
      IF(RI .LT. 0.) RI=0.
      IF(RI .GT. 3.999999) RI=3.999999
C     COMPUTE DIFFUSION COEFFICIENT
      AKY=AKYO*(1.-.25*RI)
      RETURN
      END
      SUBROUTINE DERIVD(E,U,W,DEPTH,NMAX,MMAX)
C     ....CALLED FROM DUMP VIA RUNGS....
      DIMENSION E(22)
      DIMENSION DEPTH(31,31)
      COMMON/DPASS/ NPASS,MPASS
      COMMON/DIMEN/ NS,NSP1,NVL,NSC
      COMMON /A/ EP(22)
      DIMENSION U(31,31,2),W(31,31,2)
      COMMON/BAY/ DX,DTL,XBARGE,ZBARGE,DXH,DXR,AREA
      COMMON/AMB/  NROA,IY,Y(10),ROA(10),H
      COMMON/PIECES/ PARAM(13),ROAS(13),CS(13),VFALL(13),VOIDS(13),BVOID
     1,ICOHES(12),VFALLC(13),VFALSC(20,13),VFALLD(31,31,13)
      COMMON/GUIDE1/ TDUMP,TSTOP,ISTEP,IPLUNG,NUTRL,NTRIAL,ILEAVE,
     1 KEY1,KEY2,KEY3
      COMMON/GPI/ G,PI,RB
      COMMON/STCOEF/ ALPHA,ALPHA0,ALPHAC,BETA,CDRAG,CFRIC,CD,CD1,CD2
     1, CD3,CD4,CM,DINCR1,DINCR2,FRICTN,GAMA,F1
      COMMON/COL/ A0,IBED,FBED
C
      IF(E(2).GE.0.) GO TO 30
      WRITE(6,15)
   15 FORMAT(1X ,51HDEPTH Y .LT. 0--CHANGE INPUT DATA TO ENSURE DESCENT)
      CALL EXIT
C     SET IY SO THAT CLOUD DEPTH E(2) IS BRACKETED BY Y(IY) AND Y(IY+1)
   30 IF(E(2) .LE. Y(IY+1)) GO TO 40
      IY=IY+1
      GO TO 30
   40 IF(E(2)-Y(IY)) 50,100,100
   50 IY=IY-1
      GO TO 30
C     INTERPOLATE FOR AMBIENT DENSITY AT DEPTH OF CENTROID OF CLOUD...
  100 ROAA=ROA(IY)+(E(2)-Y(IY))*(ROA(IY+1)-ROA(IY))/(Y(IY+1)-Y(IY))
      CE=(ROA(IY+1)-ROA(IY))/(Y(IY+1)-Y(IY))
      VOLUME=(E(4)+E(8))/ROA(1)
      ROO=E(4)/VOLUME
      IF (ROO .LE. ROAA) NUTRL=1
      B=(1.5*VOLUME/PI)**.333333
C
C     DETERMINE HORIZONTAL VELOCITIES AT CLOUD
      XX=XBARGE+E(1)
      ZZ=ZBARGE+E(3)
      CALL VEL(XX,E(2),ZZ,UA,WA,U,W,DEPTH,NPASS,MPASS)
C
```

```
         IF(E(9)) 110,110,120
     110 ALPHA=ALPHA0
         GO TO 200
     120 ALPHA=ALPHA0*SQRT( TANH ((G*VOLUME*(ROO-ROAA)/(2.*PI *.16*ROO*
        *                    E(9)**2*ALPHA0))**2))
C
C        MAIN COMPUTATIONS
     200 CMMASS=CM*E(4)
         UU=E(5)/CMMASS
         VV=E(6)/CMMASS
         WW=E(7)/CMMASS
         PHI=SQRT((UU-UA)**2+VV**2+(WW-WA)**2)
C        ENTRAINED VOLUME IS...
         ENTRV=2.*PI *B**2*ALPHA*PHI
         EP(1)=UU
         EP(2)=VV
         EP(3)=WW
         EP(4)=ENTRV*ROAA
         DRAG=CD*ROAA   *PI *B**2*PHI*.5
         EP(5)=ENTRV*ROAA*UA -DRAG*(UU-UA)*.5
         EP(6)=VOLUME *(ROO-ROAA)*G-DRAG*VV
         EP(7)=ENTRV*ROAA*WA-DRAG*(WW-WA)*.5
         EP(8)=ENTRV*(ROA(1)-ROAA)
         EP(9)=-3.*B**2*G*CE/ROA(1)
         DO 250 K=1,NS
         ABSWS=ABS(VFALL(K))
         IF(ABSWS-ABS(VV))220,220,230
C        IF FALL VEL. IS SMALLER  THAN THE CONVECTIVE VEL. NO SETTLING OCCURS
     220 BETAA=1.
         GO TO 240
     230 BETAA=BETA
     240 SETLV=PI*B**2*ABS(VFALL(K))*(1.-BETAA)*E(K+9)/VOLUME
         EP(4)=EP(4)-SETLV*(ROAS(K))
         EP(5)=EP(5)-SETLV*(ROAS(K))*UU
         EP(6)=EP(6)-SETLV*(ROAS(K))*VV
         EP(7)=EP(7)-SETLV*(ROAS(K))*WW
         EP(8)=EP(8)-SETLV*(ROA(1)-ROAS(K))
         EP(K+9)=-SETLV
     250 CONTINUE
         RETURN
         END
```

MODEL LISTING (46 of 85)

```
      SUBROUTINE COLAPS(SS,U,W,DEPTH,NS,NMAX,MMAX,NVL)
      DIMENSION DEPTH(31,31)
      DIMENSION U(31,31,2),W(31,31,2),SS(600,12)
      COMMON/AMB/  NROA,IY,Y(10),ROA(10),H
      COMMON/CLOUD/T(600),CX(600),CY(600),CZ(600),CU(600),CV(600)
     1, CW(600),DENDIF(600),BC(600),AA(600),FC(600),VF
      COMMON/PIECES/ PARAM(13),ROAS(13),CS(13),VFALL(13),VOIDS(13),BVOID
     1,ICOHES(12),VFALLC(13),VFALSC(20,13),VFALLD(31,31,13)
      COMMON/GUIDE1/ TDUMP,TSTOP,ISTEP,IPLUNG,NUTRL,NTRIAL,ILEAVE,
     1 KEY1,KEY2,KEY3
      COMMON/COL/ A0,IBED,FBED
      COMMON/COMP1/ E(22)
      COMMON/GPI/ G,PI,RB
      COMMON/STCOEF/ ALPHA,ALPHA0,ALPHAC,BETA,CDRAG,CFRIC,CD,CD1,CD2
     1, CD3,CD4,CM,DINCR1,DINCR2,FRICTN,GAMA,F1
      COMMON/LTCOF/ ALAMDA,DIF,AKY0
      COMMON/DTEES/ DT,DT1,DT2
      COMMON/GP/IGCN,IGCL,IGLT,IPCN,IPCL,IPLT
      COMMON/USERDT/ KEY4,DT1U,DT2U
      COMMON/FLEE/ ITD,TD(6),DC(6),CINIT,CBACK(13),CTRACE(600)
      COMMON/HA/AA1(4,31,31),AA2(4,31,31),AA3(4,31,31),AA4(4,31,31),
     1 KEYMAX
      DIMENSION SAVE(22),ACONC(12)
      EXTERNAL DERIVC
C
      DINCR=DINCR2
      NSP1=NS+1
      NTRIAL=0
      ISAV=ISTEP
      IF(ISTEP .EQ. IBED) GO TO 10
C     ....HERE IF CLOUD HAS NOT ENCOUNTERED BOTTOM....
      E1=(ROA(IY+1)-ROA(IY))/(ROA(1)*(Y(IY+1)-Y(IY)))
      EG=SQRT(E1*G)
      B1=(AA(ISTEP)**3*.84*EG*1000.)**.42857
      DT2=.001*(B1/AA(ISTEP))**3/EG*.1
      DT=DT2
      GO TO 20
C     ....HERE IF CLOUD IS ON BOTTOM....
   10 DT=DT1
      IF(KEYMAX.NE.1)GO TO 24
   20 WRITE(6,25)
   25 FORMAT(1H1,10X,23HCOLLAPSE PHASE OF CLOUD  ///10X,27HCOMPUTATIONAL
     1 INDICATORS.../5X,6HNTRIAL,4X,2HDT,6X,6HIPLUNG,2X,5HNUTRL,2X,
     2 5HISTEP,2X,4HIBED,3X,6HILEAVE )
  24 CONTINUE
     IF(KEY4 .EQ. 1) DT=DT2U
     NE=NS+10
C    SAVE STARTING VALUES IN  E  ARRAY...
     DO 100 KK=1,NE
 100 SAVE(KK)=E(KK)
C
C    ....HERE TO BEGIN A TRIAL....
 400 DO 410 KK=1,NE
 410 E(KK)=SAVE(KK)
     NTRIAL=NTRIAL+1
     ISTEP=ISAV
     VOLUME=(E(4)+E(8))/ROA(1)
     ROO=E(4)/VOLUME
     NUTRL=0
     IPLUNG=0
     IF(ISTEP .EQ. IBED )IPLUNG=1
C    IF CLOUD HAS HIT BOTTOM, GO DIRECTLY TO BOTTOM
     IF(ISTEP .EQ. IBED) GO TO 520
C    IF THIS IS FIRST TIME STEP IN COLAPS1,GO DIRECTLY TO RUNGS ROUTINE.
     IF(ISTEP .EQ. ISAV) GO TO 460
C
C    ....HERE TO BEGIN MAIN COMPUTATIONAL LOOP IN TIME....
C    ....SAVE RESULTS OF PREVIOUS COMPUTATIONS....
 420 CX(ISTEP)=E(1)
     CY(ISTEP)=E(2)
     CZ(ISTEP)=E(3)
     VOLUME=(E(4)+E(8))/ROA(1)
     CMMASS=CM*E(4)
C    E(9) IS SEMI-MAJOR AXIS
C    BC IS HORIZONTAL DIMENSION OF CLOUD
     BC(ISTEP)=2.*E(9)
C    AA IS VERTICAL DIMENSION OF CLOUD
     AA(ISTEP)=6.*VOLUME/(PI*BC(ISTEP)**2)
     CU(ISTEP)=E(5)/CMMASS
     CV(ISTEP)=E(6)/(CMMASS*BC(ISTEP))*AA(ISTEP)
     CW(ISTEP)=E(7)/CMMASS
     ROO=E(4)/VOLUME
     ROAA=ROA(IY)+(F(2)-Y(IY))*(ROA(IY+1)-ROA(IY))/(Y(IY+1)-Y(IY))
     DENDIF(ISTEP)=(ROO-ROAA)*.51545
C    SS SAVE SOLID CONCENTRATION FOR DIFFUSION
     DO 430 K=1,NS
  430 SS(ISTEP,K)=F(K+10)/VOLUME
      FC(ISTEP)=VF/VOLUME
      VINIT=2.*PI*RR**3/3.
      CTRACE(ISTEP)=(CINIT*VINIT+(VOLUME-VINIT)*CBACK(NSP1))/VOLUME
      DR=CTRACE(ISTEP)/CINIT
      IF(DR .GT. DC(ITD)) GO TO 432
      TD(ITD)=T(ISTEP)
      ITD=ITD+1
  432 CONTINUE
      IF (IPLUNG .EQ. 4) GO TO 440
      IF((CY(ISTEP)+3.*   AA(ISTEP)/8.) .GE. H) IPLUNG=2
C     AKX - CHANGE OF B BY DIFFUSION
  440 AKX=2.*ALAMDA*(   E(9))**.333333
      DBDT=.5*(BC(ISTEP)-BC(ISTEP-1))/DT
C     ....EXIT TESTS....
C     IF CLOUD TOUCHES FREE SURFACE , EXIT TO PRINTOUTS...
      IF(CY(ISTEP)-AA(ISTEP).LE.0.) GO TO 570
      IF(ISTEP .LE. ISAV+5) GO TO 450
C     IF CHANGE OF CLOUD MAJOR AXIS BY DIFFUSION IS .GT. OR EQUAL TO
C     CHANGE IN MAJOR AXIS IN ONE TIME STEP, ATTEMPT EXIT TO BEGIN
C     LONG TERM DIFFUSION....
      IF(AKX .GE. DBDT)NUTRL=3
  450 IF(NUTRL .EQ. 3) GO TO 550
C     IF CLOUD HIT BOTTOM WHILE COLLAPSING GO CALL BOTTOM1
      IF (IPLUNG .EQ. 2) GO TO 500
      IF(ISTEP .GE. 599) GO TO 550
  460 VFALLC(NS+1)=VFALL(NS+1)
      DO 455 K=1,NS
      VFALLC(K)=VFALL(K)
      IF(ICOHES(K) .EQ. 0) GO TO 455
      IF(SS(ISTEP,K) .LE. 0.0000096) VFALLC(K)=0.0017
      IF(SS(ISTEP,K) .GT. 0.00000960 .AND. SS(ISTEP,K) .LE. 0.000115)
     1VFALLC(K)=(0.00713*(SS(ISTEP,K)*2600000.)**1.33333)/304.8
      IF(SS(ISTEP,K) .GT. 0.000115) VFALLC(K)=0.047
  455 CONTINUE
      CALL RUNGS(DERIVC,NE,U,W,DEPTH,NMAX,MMAX,NVL)
      ISTEP=ISTEP+1
      T(ISTEP)=T(ISTEP-1)+DT
      GO TO 420
C     ....END OF MAJOR LOOP....
C
C     ....HERE TO COMPUTE COLLAPSE ON BOTTOM....
  500 IBFD=ISTEP
```

```
      DBT=E(10)*16./(PI*.5*AA(ISTEP)*.25*BC(ISTEP)**2*ROO)
      E(10)=ROO*PI*.5*AA(ISTEP)*.25*BC(ISTEP)**2
     1      *(DBT+.6666667*.5*BC(ISTEP)*CV(ISTEP)/(.5*AA(ISTEP)))/8.
  520 CALL BOTTOM(SS,U,W,DEPTH,NS,NEXT,NMAX,MMAX,NVL)
      GO TO (530,540,550),NEXT
  530 E(6)=CM*E(4)*CV(ISTEP)
      F(2)=CY(ISTEP)
      DBT=E(10)*9./(PI*AA(ISTEP)*.25*BC(ISTEP)**2*ROO)
      E(10)=ROO*PI *AA(ISTEP)*.50*BC(ISTEP)**2*DBT/16.
      ILEAVE=ISTEP
C     GO CALL RUNGS
      GO TO 460
  540 ISTEP=ISTEP-1
  550 IF(KEYMAX.NE.1)GO TO 552
      WRITE(6,555) NTRIAL,DT,IPLUNG,NUTRL,ISTEP,IBED,ILEAVE
  555 FORMAT(5X,I4,G12.4,I6,4I7)
  552 CONTINUE
      IF((ISTEP-ISAV ) .LE. 100 .OR. (ISTEP-ISAV ) .GE. 399) 560,570
  560 DT=DT*FLOAT(ISTEP-ISAV)*DINCR/250.
      IF(NTRIAL .GE. 5) GO TO 570
C     RETURN FOR ANOTHER TRIAL
      GO TO 400
C
C     ....HERE FOR PRINTOUT AFTER COMPUTATIONS COMPLETED....
  570 IF(IPCL.EQ.0) GO TO 600
      WRITE(6,574)
  574 FORMAT(//10X,36HX AND Z MEASURED FROM BARGE POSITION  )
      WRITE(6,575)
  575 FORMAT(/ 6X,4HTIME,8X,1HX,6X,1HY,6X,1HZ,9X,1HU,6X,1HV,5X,1HW,
     1 6X,7HDEN-DIF,6X,2HAA,4X,2HBC,8X,11HFLUID CONC.,3X,
     ,         10HSOLID-VOL.,2X,13HCONCENTRATION)
      NGRID=(ISTEP-ISAV )/60
      IF(NGRID .LT. 1) NGRID=1
      DO 599 J=ISAV,ISTEP,NGRID
      DO 580 K=1,NS
  580 ACONC(K)=4.*PI*.5*AA(J)*.25*BC(J)**2*SS(J,K)/3.
      WRITE(6,585) T(J),CX(J),CY(J) ,CZ(J),CU(J),CV(J),CW(J),DENDIF(J)
     1,AA(J),BC(J),FC(J),ACONC(1),SS(J,1)
  585 FORMAT( 1X,2F10.2,F8.2,G11.4,F6.2,F7.3,F6.2,E12.4,F7.2,G11.4,
     ,       3E12.4)
      IF(NS .EQ. 1) GO TO 599
      DO 590 K=2,NS
  590 WRITE(6,595)ACONC(K),SS(J,K)
```

```
SUBROUTINE  COLAPS                                    CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.07.05.      PAGE     5

  595 FORMAT(101X,2E12.4)
  599 CONTINUE
      DO 615 K=1,NS
      IF(ICOHES(K) .EQ. 0) GO TO 615
      WRITE(6,605) PARAM(K),VFALLC(K)
  605 FORMAT(//,10X,17HFALL VELOCITY OF ,A10,16H COMPUTED TO BE ,F10.6)
  615 CONTINUE
  600 IF(IGCL.EQ.0) GO TO 700
      ISTEP1=ISTEP+1
      T(ISTEP1)=2.*T(ISTEP)-T(ISTEP-1)
      AA(ISTEP1)=0.
      CY(ISTEP1)=0.
      BC(ISTEP1)=0.
      FC(ISTEP1)=0.
      CX(ISTEP1)=2.*CX(ISTEP)-CX(ISTEP-1)
      CZ(ISTEP1)=2.*CZ(ISTEP)-CZ(ISTEP-1)
      CALL DRAW(T,T,T,T,AA,BC,FC,CY       ,ISTEP1,2,4)
      CALL DRAW(CX,T,T,T,CZ,T,T,T,ISTEP1, 5,1)
  700 DT2=DT
      RETURN
      END


SUBROUTINE  NORM                                      CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.06.04.      PAGE     1

       SUBROUTINE NORM(A,B,N,C1,C2,AMX,AMN)
C     NORMALIZES ARRAY A WITH ARBITRARY MAX VALUE AMX, AND ARBITRARY
C     MIN VALUE AMN, INTO ARRAY B WITH MAX VALUE C1 AND MIN VALUE C2
      DIMENSION A(600),B(600)
       CALL RANGE(A,N,AMX,AMN,JMX,JMN)
       CC=C1-C2
       X=(AMX-AMN)/CC
       IF(X.EQ.0.)X=1.
       Y=(C1*AMN-C2*AMX)/CC
      Z=1./X
       DO 100 J=1,N
       B(J)=(A(J)-Y)*Z
  100 CONTINUE
       RETURN
       END
```

MODEL LISTING (51 of 85)

```
      SUBROUTINE DERIVC(E,U,W,DEPTH,NMAX,MMAX)
C     ....CALLED FROM COLAPS1  VIA RUNGS....
      DIMENSION E(22)
      DIMENSION DEPTH(31,31)
      COMMON/DPASS/ NPASS,MPASS
      COMMON /A/ EP(22)
      COMMON/BAY/ DX,DTL,XBARGE,ZBARGE,DXH,DXR,AREA
      COMMON/AMB/  NROA,IY,Y(10),ROA(10),H
      COMMON/PIECES/ PARAM(13),ROAS(13),CS(13),VFALL(13),VOIDS(13),BVOID
     1,ICOHES(12),VFALLC(13),VFALSC(20,13),VFALLD(31,31,13)
      COMMON/GPI/ G,PI,RB
      COMMON/STCOEF/ ALPHA,ALPHA0,ALPHAC,BETA,CDRAG,CFRIC,CD,CD1,CD2
     1, CD3,CD4,CM,DINCR1,DINCR2,FRICTN,GAMA,F1
      COMMON/COL/ A0,IBED,FBED
      COMMON/GUIDE1/ TDUMP,TSTOP,ISTEP,IPLUNG,NUTRL,NTRIAL,ILEAVE,
     1 KEY1,KEY2,KEY3
      COMMON/DIMEN/ NS,NSP1,NVL,NSC
      DIMENSION U(31,31,2),W(31,31,2)
C
      IF(E(2).GE.0.) GO TO 30
      WRITE(6,15)
   15 FORMAT(  47H Y LT 0 -- CHANGE INPUT DATA TO ENSURE DESCENT    )
      CALL EXIT
   30 IF(E(2) .LE. Y(IY+1)) GO TO 40
      IY=IY+1
      GO TO 30
   40 IF(E(2)-Y(IY)) 50,100,100
   50 IY=IY-1
      GO TO 30
  100 ROAA=ROA(IY)+(E(2)-Y(IY))*(ROA(IY+1)-ROA(IY))/(Y(IY+1)-Y(IY))
      CE=(ROA(IY+1)-ROA(IY))/(Y(IY+1)-Y(IY))
      VOLUME=(E(4)+E(8))/ROA(1)
      ROO=E(4)/VOLUME
C     A IS SEMIMINOR AXIS            B IS SEMIMAJOR AXIS
      B=E(9)
      A=3.*VOLUME/(4.*PI *B**2)
      ALPHA=ALPHA0*(A/B)**2
C
C     DETERMINE HORIZONTAL VELOCITIES AT CLOUD
      XX=XBARGE+E(1)
      ZZ=ZBARGE+E(3)
      CALL VEL(XX,E(2),ZZ,UA,WA,U,W,DEPTH,NPASS,MPASS)
C
```

```
SUBROUTINE  DERIVC                      CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.07.05.      PAGE     2

      CMMASS=CM*E(4)
      UU=E(5)/CMMASS
      VV=E(6)/(CMMASS*B)*A
      WW=E(7)/CMMASS
      PHI=SQRT((UU-UA)**2+VV**2+(WW-WA)**2)
C     CONTRIBUTION OF COLLAPSE TO THE TIP VELOCITY OF CLOUD
      EP(9)=E(10)*16./(PI *A*B**2*ROO)
C     COMPUTE FLUID VOLUME ENTRAINED OVER SURFACE AREA OF OBLATE SPHEROID
      A1=B**2
      A2=A1
      IF(B-A) 140,140,130
  130 RT=SQRT(B**2-A**2)
      A2=.5*(A**2*B/RT)*ALOG((B+RT)/(B-RT))
  140 ENTRV=2.*PI*(A1+A2)*(PHI*ALPHA +ALPHAC*EP(9))
C
C     MAIN COMPUTATIONS
      EP(1)=UU
      EP(2)=VV
      EP(3)=WW
      EP(4)=ENTRV*ROAA
      DRAG=   PI *ROAA*PHI*.5
      EP(5)=ENTRV*ROAA*UA-DRAG*A*B*(UU-UA)*CD3
      EP(6)=VOLUME*(ROO-ROAA)*G-DRAG*B**2*VV*CD4
      EP(7)=ENTRV*ROAA*WA-DRAG*A*B*(WW-WA)*CD3
      EP(8)=ENTRV*(ROA(1)-ROAA)
      EP(10)=      PI *(1.-GAMA*A0/A)*CE*G*A**3*B/16.
     +       -CDRAG*ROAA*A*B*EP(9)* ABS(EP(9))/4.
     +       -CFRIC*ROAA*B**2*EP(9)/(2.*A)
      DV=ENTRV*ROAA
      DO 250 K=1,NS
      ABSWS=ABS(VFALLC(K))
      IF(ABSWS-ABS(VV))220,220,230
C     IF FALL VEL. IS SMALLER THAN  THE CONVECTIVE VEL. NO SETTLING OCCURS
  220 BETAA=1.
      GO TO 240
  230 BETAA=BETA
  240 SETLV=PI*B**2*ABS(VFALLC(K))*(1.-BETAA)*E(K+10)/VOLUME
      EP(4)=EP(4)-SETLV*(ROAS(K))
      EP(5)=EP(5)-SETLV*(ROAS(K))*UU
      EP(6)=EP(6)-SETLV*(ROAS(K))*VV
      EP(7)=EP(7)-SETLV*(ROAS(K))*WW
      EP(8)=EP(8)-SETLV*(ROA(1)-ROAS(K))
      EP(K+10)=-SETLV
      DV=DV-SETLV*ROAS(K)
  250 CONTINUE
C     CONTRIBUTION OF ENTRAINMENT TO TIP VELOCITY OF CLOUD
      EP(9)=EP(9)+DV*0.375/(PI *A*B*ROO)
      RETURN
      END
```

MODEL LISTING (53 of 85)

```
      SUBROUTINE BOTTOM(SS•U•W•DEPTH•NS•NEXT•NMAX•MMAX•NVL)
      EXTERNAL DERIVB
      DIMENSION DEPTH(31•31)
      DIMENSION U(31•31•2)•W(31•31•2)•SS(600•12)
      COMMON/AMB/  NROA•IY•Y(10)•ROA(10)•H
      COMMON/CLOUD/T(600)•CX(600)•CY(600)•CZ(600)•CU(600)•CV(600)
     1• CW(600)•DENDIF(600)•BC(600)•AA(600)•FC(600)•VF
      COMMON/PIECES/ PARAM(13)•ROAS(13)•CS(13)•VFALL(13)•VOIDS(13)•BVOID
     1•ICOHES(12)•VFALLC(13)•VFALSC(20•13)•VFALLD(31•31•13)
      COMMON/GUIDE1/ TDUMP•TSTOP•ISTEP•IPLUNG•NUTRL•NTRIAL•ILEAVE•
     1 KEY1•KEY2•KEY3
      COMMON/GPI/ G•PI•RB
      COMMON/STCOEF/ ALPHA•ALPHA0•ALPHAC•BETA•CDRAG•CFRIC•CD•CD1•CD2
     1• CD3•CD4•CM•DINCR1•DINCR2•FRICTN•GAMA•F1
      COMMON/LTCOF/ ALAMDA•DIF•AKY0
      COMMON/COMP1/ E(22)
      COMMON/COL/ A0•IBED•FBED
      COMMON/FLEE/ ITD•TD(6)•DC(6)•CINIT•CBACK(13)•CTRACE(600)
      COMMON/DTEFS/ DT•DT1•DT2
C
      VFALLC(NS•1)=VFALL(NS•1)
      DO 105 K=1•NS
      VFALLC(K)=VFALL(K)
  105 CONTINUE
      NE=10•NS
      NSP1=NS•1
  100 VOLUME=(E(4)•E(8))/ROA(1)
C     E(9) IS SEMIMAJOR AXIS
      BC(ISTEP)=2.*E(9)
      AA(ISTEP)=3.*VOLUME/(2.*PI *E(9)**2)
      ROO=E(4)/VOLUME
      IF(ISTEP .NE. IBED)120•130
C     COMPUTE INITIAL BED REACTION FORCE ON PORTION OF HEMISPHERICAL
C     CLOUD THAT HAS --PASSED THRU BOTTOM--
  110 CONTINUE
      RI=H-CY(IBED)•3.*E(9)/8.
      VB=.333333*PI*RI**2*(3.*E(9)-RI)
      FBED=FBED•VB*G*(ROO-ROA(NROA))•CM*VB*ROO*CV(IBED)/DT
      GO TO 170
C
C     .....START OF COMPUTATIONAL LOOP....
  120 CX(ISTEP)=E(1)
      CY(ISTEP)=H-3.*AA(ISTEP)/8.
      CZ(ISTEP)=E(3)
      CMMASS=CM*E(4)
      CU(ISTEP)=E(5)/CMMASS
      CV(ISTEP)=.75*16.*E(10)/(PI*E(9)**3*ROO)
      CW(ISTEP)=E(7)/CMMASS
      ROAA=ROA(IY)+(E(2)-Y(IY))*(ROA(IY+1)-ROA(IY))/(Y(IY+1)-Y(IY))
      DENDIF(ISTEP)=(ROO-ROAA)*.51545
  130 FBED=0.
      DO 160 K=1,NS
      IF(ABS(CV(ISTEP)) .GT. ABS(VFALLC(K))) GO TO 140
      BETAA=1.
      GO TO 150
  140 BETAA=BETA
  150 SS(ISTEP,K)=E(K+10)/VOLUME
      IF(ICOMES(K) .EQ. 0) GO TO 155
      IF(SS(ISTEP,K) .LE. 0.0000096) VFALLC(K)=0.0017
      IF(SS(ISTEP,K) .GT. 0.00000960 .AND. SS(ISTEP,K) .LE. 0.000115)
     1VFALLC(K)=(0.00713*(SS(ISTEP,K)*2600000.)**1.33333)/304.8
      IF(SS(ISTEP,K) .GT. 0.000115) VFALLC(K)=0.047
  155 FBED=FBED-PI*E(9)      **2*ABS(VFALL(K))*ROAS(K)*SS(ISTEP,K)
     .       *(1.-BETAA)*CV(ISTEP)
  160 CONTINUE
      IF(ISTEP .EQ. IBED) GO TO 110
      FC(ISTEP)=VF/VOLUME
      VINIT=2.*PI*RB**3/3.
      CTRACE(ISTEP)=(CINIT*VINIT+(VOLUME-VINIT)*CBACK(NSP1))/VOLUME
      DR=CTRACE(ISTEP)/CINIT
      IF(DR .GT. DC(ITD)) GO TO 460
      TD(ITD)=T(ISTEP)
      ITD=ITD+1
  460 CONTINUE
      FBED=FBED+.666666*PI *AA(ISTEP)*E(9)      **2*(ROO-ROAA)*G
     1  -CM*(E(4)*CV(ISTEP)-E(6)*CV(ISTEP-1))/DT
C     AKX - CHANGE OF B BY DIFFUSION
      AKX=2.*ALAMDA*(    E(9))**.333333
      IF(E(2) .GE. H) AKX=1.0E50
      DRDT=.5*(RC(ISTEP)-RC(ISTEP-1))/DT
      IF(AKX .GE. DRDT) NUTRL=3
C     STORE OLD MASS IN E(6)
  170 E(6)=E(4)
      IF(FBED .LT. 0.) IPLUNG=4
      IF(NUTRL .NE. 3) GO TO 210
      NEXT=3
```

```
                                                CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.07.05.      PAGE       3
SUBROUTINE  BOTTOM

              RETURN
          210 IF(IPLUNG .NE. 4) GO TO 230
              ILEAVE=ISTEP
              NEXT=1
              RETURN
          230 IF(ISTEP .LT. 599) GO TO 250
              NEXT=2
              RETURN
          250 CALL RUNGS(DERIVB,NE,U,W,DEPTH,NMAX,MMAX,NVL)
              ISTEP=ISTEP+1
              T(ISTEP)=T(ISTEP-1)+DT
              GO TO 100
              END
```

```
                                                CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.06.04.      PAGE       1
SUBROUTINE  RANGE

                SUBROUTINE RANGE(A,N,AMX,AMN,JMX,JMN)
        C     GIVEN ARRAY A WITH N ELEMENTS, FIND MAX AND MIN VALUES AND
        C     CORRESPONDING INDICES
              DIMENSION A(600)
               AMX=A(1)
               JMX=1
               AMN=A(1)
               JMN=1
               DO 100 J=2,N
               IF(A(J).LT.AMX) GOTO 50
               JMX=J
               AMX=A(J)
           50  CONTINUE
               IF(A(J).GT.AMN) GOTO 100
               JMN=J
               AMN=A(J)
          100  CONTINUE
               RETURN
               END
```

MODEL LISTING (56 of 85)

```
SURROUTINE  DERIVB                            CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.07.05.      PAGE      1
      SURROUTINE DERIVB(E,U,W,DEPTH,NMAX,MMAX)
C     ....CALLED FROM BOTTOM  VIA RUNGS....
      DIMENSION E(22)
      DIMENSION DEPTH(31,31)
      DIMENSION U(31,31,2),W(31,31,2)
      COMMON/DIMEN/ NS,NSP1,NVL,NSC
      COMMON/DPASS/ NPASS,MPASS
      COMMON /A/ EP(22)
      COMMON/BAY/ DX,DTL,XBARGE,ZBARGE,DXH,DXR,AREA
      COMMON/AMB/  NROA,IY,Y(10),ROA(10),H
      COMMON/PIECES/ PARAM(13),ROAS(13),CS(13),VFALL(13),VOIDS(13),BVOID
     1,ICOHES(12),VFALLC(13),VFALSC(20,13),VFALLD(31,31,13)
      COMMON/COL/ A0,IBED,FBED
      COMMON/GPI/ G,PI,RR
      COMMON/STCOEF/ ALPHA,ALPHA0,ALPHAC,BETA,CDRAG,CFRIC,CD,CD1,CD2
     1, CD3,CD4,CM,DINCR1,DINCR2,FRICTN,GAMA,F1
      COMMON/GUIDE1/ TDUMP,TSTOP,ISTEP,IPLUNG,NUTRL,NTRIAL,ILEAVE,
     1 KEY1,KEY2,KEY3
      COMMON/DTEES/ DT,DT1,DT2
      IF(E(2) .GT. H) E(2)=H
      IF(E(2).GE.0.) GO TO 30
      WRITE(6,15)
   15 FORMAT(  47H Y LT 0 -- CHANGE INPUT DATA TO ENSURE DESCENT    )
      CALL EXIT
   30 IF(E(2) .LE. Y(IY+1)) GO TO 40
      IY=IY+1
      GO TO 30
   40 IF(E(2)-Y(IY)) 50,100,100
   50 IY=IY-1
      GO TO 30
  100 ROAA=ROA(IY)+(E(2)-Y(IY))*(ROA(IY+1)-ROA(IY))/(Y(IY+1)-Y(IY))
      CE=(ROA(IY+1)-ROA(IY))/(Y(IY+1)-Y(IY))
      VOLUME=(E(4)+E(8))/ROA(1)
      ROO=E(4)/VOLUME
C     A IS SEMIMINOR AXIS      B IS SEMIMAJOR AXIS
      B=E(9)
      A=3.*VOLUME/(2.*PI *B**2)
C
C     DETERMINE HORIZONTAL VELOCITIES AT CLOUD
      XX=XBARGE+E(1)
      ZZ=ZBARGE+E(3)
      CALL VEL(XX,E(2),ZZ,UA,WA,U,W,DEPTH,NPASS,MPASS)
C
```

MODEL LISTING (57 of 85)

```
SUBROUTINE  DERIVB

      C     CONTRIBUTION OF COLLAPSE TO TIP VELOCITY OF CLOUD
            EP(9)=E(10)*16./(PI *A*B**2*ROO)
            CMMASS=CM*E(4)
            UU=E(5)/CMMASS
            WW=E(7)/CMMASS
            PHI=SQRT((UU-UA)**2      +(WW-WA)**2)
            PH=SQRT(UU**2+WW**2)
      C     FOLLOWING STMTS ACCOUNT FOR UNIQUE NATURE OF BED FRICTION FORCE
      C     WHICH ACTS TO OPPOSE MOTION BUT NOT TO CAUSE MOTION
      C     TCOR MAKES FRICTION FORCE ACTING FOR TIME DT STOP CLOUD WHEN CLOUD
      C     VELOCITY BECOMES SMALL ENOUGH.   STMT 201 ACTS TO KEEP FRICTION FORCE
      C     ZERO AS LONG AS CLOUD IS STATIONARY.
            TCOR=1.
            IF(FBED .EQ. 0.) GO TO 120
            TCK=E(4)*PH/(FBED*FRICTN)
            IF(TCK .LT. DT) TCOR=TCK/DT
        120 CONTINUE
            IF(PH .LE. 0.001 ) 130,140
        130 PH=0.
            GO TO 150
        140 PH=1./PH
        150 CONTINUE
      C
      C     COMPUTE FLUID VOLUME ENTRAINED OVER SURFACE OF HALF OBLATE SPHEROID
            A1=B**2
            A2=A1
      C     DETERMINE ENTRAINMENT COEFFICIENT AS FUNCTION OF RICHARDSON
      C     NUMBER  (REF. KOH AND FAN(1970), P 56)
            ALPHAB=0.
            IF(PHI .LT. 1.0E-10) GO TO 160
            RI=G*(ROO-ROAA)*A/(ROAA*PHI**2)
            IF(RI .LT. 0. .OR. RI .GT. .85) GO TO 160
            ALPHAB=.075*(2./(1.+RI/.85)-1.)**1.75
        160 IF(B-A) 180,180,170
        170 RT=SQRT(B**2-A**2)
            A2=.5*(A**2*B/RT)*ALOG((B+RT)/(B-RT))
        180 ENTRV =PI*(A1+A2)*ALPHAB*EP(9)
      C     MAIN COMPUTATIONS
            EP(1)=UU
            EP(2)=0.
            EP(3)=WW
            EP(4)=ENTRV*ROAA
            DRAG=   PI *ROAA*PHI*.5
      EP(5)=ENTRV*ROAA*UA-DRAG*A*B*(UU-UA)*CD3*.5-FBED*FRICTN*UU*PH
     1 *TCOR
      EP(6)=0.
      EP(7)=ENTRV*ROAA*WA-DRAG*A*B*(WW-WA)*CD3*.5-FBED*FRICTN*WW*PH
     1 *TCOR
      EP(8)=ENTRV*(ROA(1)-ROAA)
      EP(10)=      PI *(1.-GAMA*A0/A)*CE*G*A**3*B/16.
     .+(ROO-ROAA)*G*A**2*B*(PI/4.-1./3.)
     .       -CDRAG*ROAA*A*B*EP(9)* ABS(EP(9))/4.
     .       -CFRIC*ROAA*B**2*EP(9)/(2.*A)
     .   -F1* FBED*FRICTN/(2.*PI)
      DV=ENTRV*ROAA
      DO 250 K=1,NS
      ABSWS=ABS(VFALLC(K))
      IF(ABSWS-ABS(EP(2)))220,220,230
C     IF FALL VEL. IS SMALLER THAN  THE CONVECTIVE VEL. NO SETTLING OCCURS
  220 BETAA=1.
      GO TO 240
  230 BETAA=BETA
  240 SETLV=PI*B**2*ABS(VFALLC(K))*(1.-BETAA)*E(K+10)/VOLUME
      EP(4)=EP(4)-SETLV*(ROAS(K))
      EP(5)=EP(5)-SETLV*(ROAS(K))*UU
      EP(7)=EP(7)-SETLV*(ROAS(K))*WW
      EP(8)=EP(8)-SETLV*(ROA(1)-ROAS(K))
      EP(K+10 )=-SETLV
      DV=DV-SETLV*ROAS(K)
  250 CONTINUE
C     CONTRIBUTION OF ENTRAINMENT TO TIP VELOCITY OF CLOUD
      EP(9)=EP(9)+DV* 0.75/(PI *A*B*ROO)
      RETURN
      END
```

```
SUBROUTINE  UW                                   CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.07.05.       PAGE       1
                  SUBROUTINE UW(ETS,U,W,NMAX,MMAX)
            C     ROUTINE TO READ A SET OF VELOCITIES FROM TAPE.  THESE VELOCITIES
            C     ARE CONSTANT FOR ONE TIME STEP,DTL.
                  DIMENSION U(31,31,2),W(31,31,2)
                  COMMON/DIMEN/ NS,NSP1,NVL,NSC
                  COMMON/BAY/ DX,DTL,XBARGE,ZBARGE,DXH,DXR,AREA
                  COMMON/GUIDE1/ TDUMP,TSTOP,ISTEP,IPLUNG,NUTRL,NTRIAL,ILEAVE,
                 1 KEY1,KEY2,KEY3
                  COMMON/VSPECS/ IFORM,DU1,DU2,UU1,UU2,DW1,DW2,WW1,WW2,DL1,DL2
                  INTEGER SKIP
                  IF(IFORM .EQ. 4) RETURN
                  ICYCLE=ETS/90000.+1.
                  SKIP=1
            C     TTAPE RELATES TAPE TIME TO ELAPSED TIME
                  TTAPE=ETS+TDUMP
                  TSHIFT=FLOAT(ICYCLE-1)*90000.
                  TTAPE=TTAPE-TSHIFT
                  IF(NVL .GT. 1) GO TO 200
            C
            C     HERE FOR SINGLE LAYER
               50 READ(7) TUW
                  IF((TUW+.01) .LT. 90000.) GO TO 70
                  REWIND 7
                  GO TO 50
               70 CONTINUE
                  IF(ABS(TUW-TTAPE) .LT. .01) SKIP=0
                  READ (7) ((U(N,M,1),N=1,NMAX),M=1,MMAX)
                 1         ,((W(N,M,1),N=1,NMAX),M=1,MMAX)
                  IF(SKIP .EQ. 1) GO TO 50
                  RETURN
            C
            C     HERE FOR MULTI-LAYER VELOCITIES
              200 CONTINUE
              250 READ (7) TUW
                  IF((TUW+.01) .LT. 90000.) GO TO 270
                  REWIND 7
                  GO TO 250
              270 CONTINUE
                  IF(ABS(TUW-TTAPE) .LT. .01) SKIP=0
                  READ(7) DL1,DL2
                  DO 280 L=1,NVL
                  READ (7) ((U(N,M,L),N=1,NMAX),M=1,MMAX)
                 1         ,((W(N,M,L),N=1,NMAX),M=1,MMAX)
              280 CONTINUE
                  IF(SKIP .EQ. 1) GO TO 250
                  RETURN
                  END
```

MODEL LISTING (60 of 85)

```
SUBROUTINE  VEL                                  CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.07.05.       PAGE      1

                    SUBROUTINE VEL(XA,YA,ZA,UA,WA,U,W,DEPTH,NMAX,MMAX)
              C     SUBROUTINE TO SUPPLY HORIZONTAL VELOCITY DATA, GIVEN X,Y,Z,T
                    DIMENSION DEPTH(31,31)
                    COMMON/BAY/ DX,DTL,XBARGE,ZBARGE,DXH,DXR,AREA
                    COMMON/DIMEN/ NS,NSP1,NVL,NSC
                    COMMON/VSPECS/ IFORM,DU1,DU2,UU1,UU2,DW1,DW2,WW1,WW2,DL1,DL2
                    DIMENSION U(31,31,2),W(31,31,2)
                    DIMENSION UI(4),WI(4)
                    IF(IFORM .EQ. 4) GO TO 500
                    XX=XA
                    ZZ=ZA
              C     DETERMINE HORIZONTAL COORDINATES OF 4 POINTS SURROUNDING (XX,ZZ) AND
              C     WEIGHT FACTORS FOR INTERPOLATION
                 30 ZN=ZZ*DXR
                    XM=XX*DXR
                    N=ZN+.0001
                    M=XM+.0001
                    EN=ZN-FLOAT(N)
                    EM=XM-FLOAT(M)
                    IF(EN .LT. .0001) FN=0.
                    IF(EM .LT. .0001) EM=0.
              C     IF MORE THAN ONE LAYER, BRANCH
                    IF(IFORM .EQ. 3) GO TO 300
              C     HERE TO INTERPOLATE FOR VELOCITIES IN SINGLE LAYER
                    UA1=U(N,M,1)+EN*(U(N+1,M,1)-U(N,M,1))
                    WA1=W(N,M,1)+EN*(W(N+1,M,1)-W(N,M,1))
                    UA2=U(N,M+1,1)+EN*(U(N+1,M+1,1)-U(N,M+1,1))
                    WA2=W(N,M+1,1)+EN*(W(N+1,M+1,1)-W(N,M+1,1))
                    UA=UA1+EM*(UA2-UA1)
                    WA=WA1+EM*(WA2-WA1)
              C     IF USING LOG PROFILE CORRECT VELOCITIES AS APPROPRIATE...IF NOT, RETURN
                    IF(IFORM .EQ. 1) GO TO 100
                    CALL DINT(XX,ZZ,DD,DEPTH,NMAX,MMAX)
                    COR=0.
                    IF(YA/DD .GT. .99) GO TO 50
                    COR=1.+.476*(1.+ALOG((DD-YA)/DD))/DD**.666666
                 50 CONTINUE
                    UA=UA*COR
                    WA=WA*COR
                100 RETURN
              C
              C     HERE FOR MULTI-LAYER VELOCITIES
                300 CONTINUE
```

```
      DO 380 I=1,4
      NI=N
      MI=M
      IF(I .EQ. 2 .OR. I .EQ. 3) NI=NI+1
      IF(I .EQ. 3 .OR. I .EQ. 4) MI=MI+1
      IF(DEPTH(NI,MI) .LE. 0.) GO TO 360
      DD1=DL1*DEPTH(NI,MI)
      DD2=DL2*DEPTH(NI,MI)
      IF(YA .GT. DD1) GO TO 320
      UI(I)=U(NI,MI,1)
      WI(I)=W(NI,MI,1)
      GO TO 380
  320 IF(YA .GT. DD2) GO TO 340
      FRAC=(YA-DD1)/(DD2-DD1)
      UI(I)=U(NI,MI,1)+FRAC*(U(NI,MI,2)-U(NI,MI,1))
      WI(I)=W(NI,MI,1)+FRAC*(W(NI,MI,2)-W(NI,MI,1))
      GO TO 380
  340 FRAC=(YA-DD2)/(DEPTH(NI,MI)-DD2)
      UI(I)=U(NI,MI,2)+FRAC*(0.-U(NI,MI,2))
      WI(I)=W(NI,MI,2)+FRAC*(0.-W(NI,MI,2))
      GO TO 380
  360 UI(I)=0.
      WI(I)=0.
  380 CONTINUE
      UA1=UI(1)+EN*(UI(2)-UI(1))
      WA1=WI(1)+EN*(WI(2)-WI(1))
      UA2=UI(3)+EN*(UI(4)-UI(3))
      WA2=WI(3)+EN*(WI(4)-WI(3))
      UA=UA1+EM*(UA2-UA1)
      WA=WA1+EM*(WA2-WA1)
      RETURN
C     ...HERE TO INTERPRET --QUICK LOOK-- VELOCITY PROFILES....
  500 CONTINUE
      IF(YA .LE. DU1) GO TO 510
      IF(YA .GE. DU2) GO TO 520
      UA=UU1+(UU2-UU1)*(YA-DU1)/(DU2-DU1)
      GO TO 550
  510 UA=UU1
      GO TO 550
  520 CALL DINT(XA,ZA,DD,DEPTH,NMAX,MMAX)
      UA=UU2+(0.-UU2)*(YA-DU2)/(DD-DU2)
  550 CONTINUE
      IF(YA .LE. DW1) GO TO 560
```

```
SUBROUTINE  VEL                              CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.07.05.      PAGE      3
            IF(YA .GE. DW2) GO TO 570
            WA=WW1+(WW2-W     *(YA-DW1)/(DW2-DW1)
            GO TO 600
        560 WA=WW1
            GO TO 600
        570 CALL DINT(XA,ZA,DD,DEPTH,NMAX,MMAX)
            WA=WW2+(0.-WW2)*(YA-DW2)/(DD-DW2)
        600 RETURN
            END
```

```
SUBROUTINE  RUNGS                            CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.07.05.      PAGE      1
            SUBROUTINE RUNGS(DERIVE,NE,U,W,D,NMAX,MMAX,NVL)
            COMMON/COMP1/ E(22)
            COMMON /A/ EP(22)
            COMMON/DTEES/ DT,DT1,DT2
            DIMENSION W1(22),W2(22),W3(22),W4(22),Z(22)
            DIMENSION D(31,31),U(31,31,2),W(31,31,2)
      C
      C
            CALL DERIVE(E,U,W,D,NMAX,MMAX)
            DO 2 I=1,NE
            W1(I)=DT*EP(I)
          2 Z(I)=E(I)+ W1(I)*0.5
            CALL DERIVE(Z,U,W,D,NMAX,MMAX)
            DO 3 I=1,NE
            W2(I)=DT*EP(I)
          3 Z(I)=E(I)+W2(I)*0.5
            CALL DERIVE(Z,U,W,D,NMAX,MMAX)
            DO 4 I=1,NE
            W3(I)=DT*EP(I)
          4 Z(I)=E(I)+W3(I)
            CALL DERIVE(Z,U,W,D,NMAX,MMAX)
            DO 7 I=1,NE
            W4(I)=DT*EP(I)
          7 E(I)=E(I)+(2.*(W2(I)+W3(I))+W1(I)+W4(I))/6.
            RETURN
            END
```

MODEL LISTING (63 of 85)

```
      SUBROUTINE DRAW (X1,X2,X3,X4,Y1,Y2,Y3,Y4,N,IG,NCURV)
C     GRAPHING ROUTINE
C     X1,X2,X3,X4--INDEPENDENT VARIABLES
C     Y1,Y2,Y3,Y4--DEPENDENT VARIABLES
C     N--NUMBER OF POINTS AVAILABLE FOR PLOTTING
      DIMENSION X1(600),X2(600),X3(600),X4(600),Y1(600),Y2(600),
     1Y3(600),Y4(600),X(600),
     *Y(600),YY(600),SYM(4),SIM(20),P(2400)
      DATA SIM/1HY,1HB,1HC,1HS,1HA,1H1,1H2,1H3,1H4,1H5,1H6,1H7,1H8,1HT,
     * 1HX,1HZ,1H.,1H+,1H*,1H0/                                        NON-ANSI
      IF(NCURV.LT.1) RETURN
C     NX IS NUMBER OF LINES FOR INDEPENDENT VARIABLE
C     NY  IS NUMBER OF COLUMNS FOR DEPENDENT VARIABLE
      NX=50
      NY=101
      NSCALE=60
      IN = N/NSCALE
      IF(IN.LT.1) IN=1
C
C     PLACE VARIABLES IN PLOT ARRAYS
      J=0
      DO 1 I=1,N,IN
      J=J+1
      X(J)=X1(I)
    1 Y(J)=Y1(I)
      J=J+1
      X(J)=X1(N)
      Y(J)=Y1(N)
      NN=J
      IF(NCURV.EQ.1) GO TO 5
      DO 2 I=1,N,IN
      J=J+1
      X(J)=X2(I)
    2 Y(J)=Y2(I)
      J=J+1
      X(J)=X2(N)
      Y(J)=Y2(N)
      IF(NCURV.EQ.2) GO TO 5
      DO 3 I=1,N,IN
      J = J+1
      X(J)=X3(I)
    3 Y(J)=Y3(I)
      J=J+1
```

```
            X(J)=X3(N)
            Y(J)=Y3(N)
            IF(NCURV.EQ.3) GO TO 5
            DO 4 I=1,N,IN
            J=J+1
            X(J)=X4(I)
          4 Y(J)=Y4(I)
            J=J+1
            X(J)=X4(N)
            Y(J)=Y4(N)
          5 CONTINUE
            GO TO (10,20,50,60,2000,1000,3000),IG
      C
         10 SYM(1)=SIM(1)
            SYM(2)=SIM(2)
            SYM(3)=SIM(15)
            SYM(4)=SIM(16)
            CALL NORM(Y,YY,NN,1.,0.,AMXY,AMNY)
            NN1=NN+1
            CALL NORM(Y(NN1),YY(NN1),NN,1.0,0.,AMXB,AMNB)
            NN1=NN1+NN
            CALL NORM(Y(NN1),YY(NN1),NN,1.0,0.,AMXC,AMNC)
            NN1=NN1+NN
            CALL NORM (Y(NN1),YY(NN1),NN,1.0,0.,AMXS,AMNS)
            WRITE(6,15)   X(1),X(NN),AMXY,AMXB,AMXC,AMXS,AMNY,AMNB,AMNC,AMNS
         15 FORMAT(1H1/////10X,59HPLOT OF CLOUD PATH AND RADIUS AS SEEN FROM P
           1OINT OF RELEASE ///10X,45HINDEPENDENT VARIABLE IS TIME (SEC) OVER
           2RANGE,2X,2G13.5///10X,61HDEPENDENT VARIABLES, ALL NORMALIZED FOR P
           3LOTTING ON UNIT AXIS//10X,6HSYMBOL,13X,1HY,17X,1HB,15X,1HX,15X,1HZ
           4//10X,11HMAX PLOTTED,3X,G12.5,3(6X,G12.5)/10X
           5, 11HMIN PLOTTED,3X,G12.5,3(6X,G12.5)/10X
           6, 7HREMARKS,8X,5HDEPTH,13X,6HRADIUS,12X,12HHOR DIST(CX),6X,12HHOR
           7DIST(CZ) )
            CALL SPLOT(YY,X,P,J,NY,NX,NN,4,SYM)
            RETURN
      C
         20 SYM(1)=SIM(5)
            SYM(2)=SIM(2)
            SYM(3)=SIM(3)
            SYM(4)=SIM(1)
            CALL NORM (Y,YY,NN,1.,0.,AMXA,AMNA)
            NN1=NN+1
            CALL NORM (Y(NN1),YY(NN1),NN,1.,0.,AMXB,AMNB)
```

MODEL LISTING (65 of 85)

```
      NN1=NN1+NN
      CALL NORM (Y(NN1),YY(NN1),NN,1.,0.,AMXC,AMNC)
      NN1=NN1+NN
      CALL NORM (Y(NN1),YY(NN1),NN,1. ,0.,AMXY,AMNY)
      WRITE(6,25) X(1),X(NN),AMXA,AMXB,AMXC,AMXY,AMNA,AMNB,AMNC,AMNY
   25 FORMAT(1H1/////10X,40HPLOT OF COLLAPSING CLOUD CHARACTERISTICS///
     1,10X,39HINDEPENDENT VARIABLE IS TIME OVER RANGE,2X,2G13.5///10X,
     2 60HDEPENDENT VARIABLE, ALL NORMALIZED FOR PLOTTING ON UNIT AXIS//
     3 10X,6HSYMBOL,13X,1HA,17X,1HB,13X,1HC,13X,1HY/10X,11HMAX PLOTTED,
     4 3X,G12.5,4X,3(2X,G12.5)/10X,11HMIN PLOTTED,3X,G12.5,4X,3(2X,G12.5
     5)/10X,7HREMARKS,8X,9HVERT SIZE,9X,8HHOR SIZE,4X,13HCONCENTRATION
     6 ,3X,6HDEPTH )
      CALL SPLOT(YY,X,P,J,NY,NX,NN,4,SYM)
      RETURN
C
   50 DO 51 I=1,4
   51 SYM(I)=SIM(I+5)
   52 CALL RANGE(Y,J,AMXS,AMNS,JMX,JMN)
      WRITE(6,500) X(1),X(NN),AMNS,AMXS
      CALL SPLOT( Y,X,P,J,NY,NX,NN,NCURV,SYM)
  500 FORMAT(1H1,/////,2X,31HGRAPH OF WASTE  CONCENTRATIONS  ,//,
     * 2X,12HRANGE OF X  ,20X,2G20.8,/ ,2X,32HRANGE OF CONCENTRATIONS PL
     1OTTED   ,  2G20.8, 8(/))
      RETURN
C
   60 DO 61 I=1,4
   61 SYM(I)=SIM(I+9)
      GO TO 52
C
 1000 DO 1001 I=2,4
 1001 SYM(I)=SIM(I+4)
      SYM(1)=SIM(3)
      GO TO 52 .
C
 3000 CONTINUE
      DO 3001 I=1,4
 3001 SYM(I)=SIM(I+16)
      GO TO 52
C
 2000 SYM(1)=SIM(15)
      CALL RANGE(Y,J,AMX,AMN,JMX,JMN)
      IF(AMN.EQ.0..AND.AMX.EQ.0.) RETURN
      WRITE(6,2001) X(1),X(NN),AMN,AMX
 2001 FORMAT(1H1,11(/),20X,15HGRAPH OF X VS Z,//,2X,10HRANGE OF X,
     *2G20.8,/,2X,10HRANGE OF Z,2G20.8)
      CALL SPLOT(Y,X,P,J,NY,NX,NN,NCURV,SYM)
      RETURN
      END
 SUBROUTINE  SPLOT                         CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.07.05.       PAGE      1

                 SUBROUTINE SPLOT(B,A,P,N,L,M,NREP,NSYM,SYM)
           C     PRINTER PLOT ROUTINF
           C     NSYM--NUMBER OF GRAPHS PLOTTED ON THIS FRAME
           C     M--NUMBER OF SPACES DOWN THE PAGE
           C     L--NUMBER OF SPACES ACROSS THE PAGE
                 DIMENSION A(600),B(600),SYM(4),P(2400),Q(20),H(10)
                  DATA Q/20*5H----I/                                         NON-ANSI
                 DATA BL5/5H     /
                  DATA EYE/1HI/
           C     SET GRAPH FIELD TO BLANKS
                  LOLD=L
                 L5=L/5
                 L=5*L5
                 LQ=L5-1
                  ML=(M+1)*(L5+1)
                 DO 10 J=1,ML
              10 P(J)=BL5
           C     DETERMINE MAX AND MIN OF INDEPENDENT VARIABLE A AND DEPENDENT
           C     VARIABLE B AND THE INCREMENT OF EACH CORRESPONDING TO ONE PRINTER
           C     PRINT POSITION IN EACH DIRECTION
                 CALL RANGE(A,N,AMX,AMN,JMX,JMN)
                 CALL RANGE(B,N,BMX,BMN,JMX,JMN)
                 DIV=5.
                 IF(AMX .GT. 100.) DIV=10.
                 IAMX=AMX/DIV
                 AMX=DIV*FLOAT(IAMX)+DIV
                  DA=(AMX-AMN)/FLOAT(M)
                  DB=(BMX-BMN)/FLOAT(L)
                  WRITE(6,2000) AMX,AMN,DA
            2000 FORMAT(/////,1X,26HMAX,MIN,INC, OF IND.VAR.    ,/,1X,6G20.8)
                 WRITE(6,2001) BMX,BMN,DB
            2001 FORMAT(//,1X,26HMAX,MIN,INC, OF DEP. VAR.    ,/,1X,6G20.8)
                 WRITE(6,2002)
            2002 FORMAT(1H1)
           C     DETERMINE AND PRINT TOP (DEPENDENT AXIS) LABEL AND LINE
                  JZA=0
                  ZRO=0.
                  TESTA=AMX*AMN
                  TESTB=BMX*BMN
                  IF(TESTA)50,60,60
              50  JZA=-AMN/DA
              60 IF(TESTB) 70,90,90
              70  IB=-BMN/DB
```

MODEL LISTING (67 of 85)

```
        LIA=-L5
       DO 80 J=1,M
        LIA=LIA+L5
   80   CALL PFIX(P,IB,LIA,EYE)
   90   L10=LOLD/20+1
        DB20=20.*DB
       DO 100 J=1,L10
  100  H(J)=BMN+FLOAT(J-1)*DB20
       HMAX=ALOG10(ABS(H(L10)))+.0001
       IF(HMAX .LT. 0.) GO TO 106
       IF(HMAX .GE. 1.) GO TO 109
       WRITE(6,105) (H(J),J=1,L10)
  105  FORMAT(14X,F3.1,5(17X,F3.1))
       GO TO 114
  106  WRITE(6,108)(H(J),J=1,L10)
  108  FORMAT(14X,F6.4,5(14X,F6.4))
       GO TO 114
  109  WRITE(6,110)(H(J),J=1,L10)
  110  FORMAT(12X,F6.2,5(14X,F6.2))
  114   WRITE(6,115 ) (Q(J),J=1,20)
  115  FORMAT(15X,1HI,20A5)
C
C      ENCODE PLOT POINTS
       DO 200 J=1,N
        IA=(A(J)-AMN)/DA
        LIA=L5*IA
        IB=(B(J)-BMN)/DB
       JZZ=(J-1)/NREP
        ISYM=JZZ-(JZZ/NSYM)*NSYM+1
        CALL PFIX(P,IB,LIA,SYM(ISYM))
 200    CONTINUE
C
C      PRINT GRAPH
        DO 300 J=1,M
        JQ=(J/10)*10
        JLO=J*L5-LQ
        JHI=JLO+LQ
       WRITE(6,255) (P(K),K=JLO,JHI)
  255  FORMAT(15X,1HI,20A5)
        IF(J.EQ.JZA) WRITE(6,265 ) ZRO,(Q(K),K=1,20)
  265  FORMAT(1H+,G13.5,2X,20A5)
        IF(JQ.NE.J) GO TO 300
        DAJ=AMN+DA*FLOAT(J)
        WRITE(6,265 ) DAJ,(Q(K),K=1,20)
 300    CONTINUE
        RETURN
        END
```

MODEL LISTING (68 of 85)

```
      SUBROUTINE BOOKS(K,SS,TSIDE,TTHK,TTOP,TMASS,TX,TZ,NS,DEPTH,ACCUM
     1, U,W,NMAX,MMAX,NSC,NVL)
C     DUMP MODEL
C     BOOKKEEPING ROUTINE FOR MASS TRANSFER FROM SHORT TO LONG TERM
C     TAKEN ONE COMPONENT (INDEX K)  AT A TIME
      DIMENSION ACCUM(31,31),TSIDE(100),TTHK(100),
     1           TTOP(100),TMASS(100),TX(100),TZ(100)
      DIMENSION U(31,31,2),W(31,31,2),SS(600,12)
      DIMENSION DEPTH(31,31)
      COMMON/HA/AA1(4,31,31),AA2(4,31,31),AA3(4,31,31),AA4(4,31,31),
     1 KEYMAX
      COMMON/NC/ NTCLD
      COMMON/CLOUD/T(600),CX(600),CY(600),CZ(600),CU(600),CV(600)
     1, CW(600),DENDIF(600),RC(600),AA(600),FC(600),VF
      COMMON/PIECES/ PARAM(13),ROAS(13),CS(13),VFALL(13),VOIDS(13),BVOID
     1,ICOHES(12),VFALLC(13),VFALSC(20,13),VFALLD(31,31,13)
      COMMON/GUIDE1/ TDUMP,TSTOP,ISTEP,IPLUNG,NUTRL,NTRIAL,ILEAVE,
     1 KEY1,KEY2,KEY3
      COMMON/BAY/ DX,DTL,XBARGE,ZBARGE,DXH,DXR,AREA
      COMMON/COL/ A0,IBED,FBED
      COMMON/LTCOF/ ALAMDA,DIF,AKY0
      COMMON/SWITCH/ ITF
      COMMON/GPI/ G,PI,RB
      COMMON/FLEE/ ITD,TD(6),DC(6),CINIT,CBACK(13),CTRACE(600)
      COMMON/ENTRAN/ TEMAS(100),VOLSC(100)
      NSP1=NS+1
      DO 50 I=1,100
      VOLSC(I)=0.0
   50 TEMAS(I)=0.0
      NTCLD=0
      C1=2.*PI/3.
      NEWT=1
      INCT=ISTEP/10
C     INCT IS INCREMENT OF STEPS TO CHECK SHORT TERM
C
      IF(K  .EQ. NSP1) GO TO 300
  100 CONTINUE
      LAST=NEWT
  102 NEWT=NEWT+INCT
C     AT LAST STEP IN SHORT TERM SET TO CREATE FINAL CLOUD OF THIS
C     MATERIAL
      IF(NEWT .GT. ISTEP) NEWT=ISTEP
C
```

MODEL LISTING (69 of 85)

```
C     ...HERE TO CHECK IF SOLIDS HAVE LEFT CLOUD IN LATEST TIME INTERVAL
C        L  IS INDICATOR OF CHANGE OF COMPUTATION PHASE DURING SHORT
C           TERM
C        VLOSS IS SOLID VOLUME LOSS FROM CLOUD
      IF(T(NEWT) .LE. T(ITF)) GO TO 120
      IF(T(LAST) .GT. T(ITF)) GO TO 140
C
C     BETWEEN CONVECTIVE DESCENT AND DYNAMIC COLLAPSE
      VV=   C1*SS(LAST,K)*AA(LAST)**3
      VLOSS=VV-.25*C1*SS(NEWT,K)*AA(NEWT)*BC(NEWT)**2
      L=2
      GO TO 200
C
C     IN CONVECTIVE DESCENT PHASE
  120 CONTINUE
      VV=C1*SS(LAST,K)*AA(LAST)**3
      VLOSS=VV-C1*SS(NEWT,K)*AA(NEWT)**3
      L=1
      GO TO 200
C
C     IN DYNAMIC COLLAPSE PHASE
  140 CONTINUE
      VV=.25*C1*SS(LAST,K)*AA(LAST)*BC(LAST)**2
      VLOSS=VV-.25*C1*SS(NEWT,K)*AA(NEWT)*BC(NEWT)**2
      L=3
  200 CONTINUE
C     AT FINAL SHORT TERM TIME STEP, VOLUME OF NEW CLOUD IS ALL
C     REMAINING MATERIAL IN CLOUD
      IF(NEWT .EQ. ISTEP) VLOSS=VV
C     IF VOLUME LOSS FOR THIS TIME INTERVAL IS ZERO, INCREMENT TO NEXT
C     TIME STEP
      IF(NEWT .EQ. ISTEP) GO TO 210
      IF(VLOSS .EQ. 0.)GO TO 100
      IF((VLOSS/VV) .LT. 1.0E-03) GO TO 102
C
C     ...HERE TO CREATE SOLIDS CLOUDS...
  210 NTCLD=NTCLD+1
      IF(NTCLD .LE. NSC) GO TO 219
      WRITE(6,205)
  205 FORMAT(//10X,38HSMALL CLOUDS ARRAYS FILLED...CALL EXIT /10X,
     1 39HUSER SHOULD INCREASE INPUT VARIABLE NSC  )
      CALL EXIT
  219 CONTINUE
```

```
      TMASS(NTCLD)=VLOSS
      TTHK(NTCLD)=VFALLC(K)*(T(NEWT)-T(LAST))
      IF(NEWT .EQ. ISTEP)TTHK(NTCLD)=TTHK(NTCLD)+AA(ISTEP)
C     HORIZONTAL POSITION MEASUREMENT NOW TRANSLATED SO THAT IT IS W/R
C     TO ESTUARY COORDINATES
      TX(NTCLD)=CX(NEWT)+XBARGE
      TZ(NTCLD)=CZ(NEWT)+ZBARGE
      CALL DINT(TX(NTCLD),TZ(NTCLD),D3,DEPTH,NMAX,MMAX)
      GO TO(220,240,240),L
  220 TTOP(NTCLD)=CY(NEWT)+3.*AA(NEWT)/8.
      IF(NEWT .EQ. ISTEP)TTOP(NTCLD)=TTOP(NTCLD)-3.*AA(NEWT)/4.
      GO TO 250
  240 TTOP(NTCLD)=CY(NEWT)+AA(NEWT)*.5
      IF(IBED .NE. 0 .AND. NEWT .GT. IBED .AND. NEWT .LT. ILEAVE)
     1 TTOP(NTCLD)=D3
      IF(NEWT .EQ. ISTEP)TTOP(NTCLD)=TTOP(NTCLD)-AA(NEWT)
  250 CONTINUE
      IF((TTOP(NTCLD)+TTHK(NTCLD)) .GT. D3) TTOP(NTCLD)=D3-TTHK(NTCLD)
C     TSIDE IS SIDE OF SQUARE WITH AREA EQUAL TO AREA OF CIRCULAR
C     SHORT TERM CLOUD
      TSIDE(NTCLD)=0.886266*BC(NEWT)
      VFALSC(NTCLD,K)=VFALL(K)
      IF(ICOHES(K) .EQ.0) GO TO 251
      SCONC=(TMASS(NTCLD)/(TSIDE(NTCLD)**2*TTHK(NTCLD)))*2600000.
      IF(SCONC .LE. 25.)VFALSC(NTCLD,K)=0.0017
      IF(SCONC .GT. 25. .AND.  SCONC .LE. 300.) VFALSC(NTCLD
     1,K)=(0.00713*SCONC**1.33333)/304.8
      IF(SCONC .GT. 300.) VFALSC(NTCLD,K)=0.047
  251 CONTINUE
      IF(KEYMAX.NE.1)GO TO 500
  253 WRITE(6,255) NTCLD,T(NEWT),TX(NTCLD),TZ(NTCLD),TSIDE(NTCLD)
     1,TTOP(NTCLD),TTHK(NTCLD),TMASS(NTCLD),TEMAS(NTCLD),NEWT,LAST
  500 CONTINUE
  255 FORMAT(//1X,27HNEW CLOUD CREATED, NTCLD = ,I5/3X,6HT(SEC),8X,2HTX
     1,10X,2HTZ,9X,5HTSIDE,8X,3HTOP,8X,4HTTHK,8X,5HTMASS,8X,5HTEMAS,8X,
     24HNEWT,7X,4HLAST,/1X,8G12.4,4X,I4,6X,I4)
      GO TO 400
C
C     ...HERE TO CREATE FINAL FLUID CLOUD...
  300 NTCLD=NTCLD+1
      NEWT=ISTEP
      TX(NTCLD)=CX(ISTEP)+XBARGE
      TZ(NTCLD)=CZ(ISTEP)-ZBARGE
      CALL DINT(TX(NTCLD),TZ(NTCLD),D3,DEPTH,NMAX,MMAX)
      TSIDE(NTCLD)=.886226*BC(ISTEP)
      VINIT=C1*RB**3
      IF(ISTEP .GT. ITF) GO TO 340
      TTOP(NTCLD)=CY(ISTEP)-3.*AA(ISTEP)/8.
      TEMAS(NTCLD)=(C1*AA(ISTEP)**3-VINIT)*CBACK(NSP1)
      TMASS(NTCLD)=CINIT*VINIT+TEMAS(NTCLD)
      GO TO 350
  340 TTOP(NTCLD)=CY(ISTEP)-AA(ISTEP)*.5
      IF(IBED .NE. 0 .AND. NEWT .GT. IBED .AND. NEWT .LT. ILEAVE)
     1 TTOP(NTCLD)=D3-AA(ISTEP)
      TEMAS(NTCLD)=(C1*2.*AA(ISTEP)*BC(ISTEP)**2/8.0-VINIT)*CBACK(NSP1)
      TMASS(NTCLD)=CINIT*VINIT+TEMAS(NTCLD)
  350 CONTINUE
C
      TTHK(NTCLD)=TMASS(NTCLD)/(CTRACE(ISTEP)*TSIDE(NTCLD)**2)
      IF((TTOP(NTCLD)+TTHK(NTCLD)) .GT. D3) TTOP(NTCLD)=D3-TTHK(NTCLD)
      GO TO 253
  400 DELT=DTL   -T(NEWT)
      IF(DELT.GE.0.) GO TO 402
      WRITE(6,2001)
 2001 FORMAT(//54H DTL .LT. SHORT TERM CALCULATIONS - ADJUST AND RERUN
     ,  )
      CALL EXIT
C     ...UPDATE LATEST CLOUD TO 1/2 HOUR AFTER DUMP
  402 IF(K .EQ. NSP1) VOL=TTHK(NTCLD)*TSIDE(NTCLD)**2
      DTOP=0.
      CALL DINT(TX(NTCLD),TZ(NTCLD),D1,DEPTH,NMAX,MMAX)
      IF(TTOP(NTCLD) .EQ. D1)GO TO 410
C     ...CONVECT...
C     DETERMINE HORIZONTAL VELOCITIES
      YY=TTOP(NTCLD)+.5*TTHK(NTCLD)
      CALL VEL(TX(NTCLD),YY,TZ(NTCLD),UA,WA,U,W,DEPTH,NMAX,MMAX)
      TX(NTCLD)=TX(NTCLD)+UA*DELT
      TZ(NTCLD)=TZ(NTCLD)+WA*DELT
C     CHECK FOR SMALL CLOUD PASSING OUT OF GRID BOUNDARY
      NCHK=TZ(NTCLD)*DXR
      MCHK=TX(NTCLD)*DXR
      IF(NCHK .LT. 1 .OR. NCHK .GT. NMAX .OR. MCHK .LT. 1 .OR. MCHK .GT.
     1  MMAX) WRITE(6,405)
  405 FORMAT(/5X,101H---WARNING---A SMALL CLOUD HAS PASSED OUT OF GRID B
     1OUNDARY IN SUBROUTINE BOOKS...ERRORS WILL OCCUR---  )
      CALL DINT(TX(NTCLD),TZ(NTCLD),D2,DEPTH,NMAX,MMAX)
```

```
          C      DTOP ESTIMATES VARIATION OF CLOUD DEPTH DUE TO CONVECTION OVER
          C      VARYING DEPTHS
                 DTOP=(D1-D2)*TTOP(NTCLD)/D1
          C      ...DIFUSE HORIZONTALLY...
                 TSIDE(NTCLD)=TSIDE(NTCLD)*(1.+(1.333333*ALAMDA/TSIDE(NTCLD)**
                1 .666666)*DELT)**1.5
          C      ...DIFUSE VERTICALLY...
                 DO 1000 IDELT=1,10
                 OTOP=TTOP(NTCLD)
                 MX=TX(NTCLD)*DXR+.5
                 NZ=TZ(NTCLD)*DXR+.5
                 CALL VDIFCO(NZ,MX,OTOP,DCO,U,W,DEPTH,NMAX,MMAX,NVL)
                 DINK=2.0*SQRT(DCO*DELT/10.0)
                 TTOP(NTCLD)=TTOP(NTCLD)-DINK
                 IF(TTOP(NTCLD) .LT. 0.) TTOP(NTCLD)=0.
                 OBOT=OTOP+TTHK(NTCLD)
                 IF(OBOT .GT. D2) OBOT=D2
                 CALL VDIFCO(NZ,MX,OBOT,DCO,U,W,DEPTH,NMAX,MMAX,NVL)
                 DONK=2.0*SQRT(DCO*DELT/10.0)
                 IF((OBOT+DONK) .GT. D2) DONK=D2-OBOT
                 TTHK(NTCLD)=TTHK(NTCLD)+DINK+DONK
                 IF((OTOP+TTHK(NTCLD)) .GT. D2) TTHK(NTCLD)=D2-TTOP(NTCLD)
                 VOLSC(NTCLD)=TTHK(NTCLD)*TSIDE(NTCLD)**2
            1000 CONTINUE
          C      ...SETTLE...
             410 IF(K  .EQ. NSP1) GO TO 440
                 DIST=VFALSC(NTCLD,K)*DELT
                 MX=TX(NTCLD)*DXR+.5
                 NZ=TZ(NTCLD)*DXR+.5
             411 XS=D2-TTOP(NTCLD)-TTHK(NTCLD)-DTOP
                 HS=0.5*TSIDE(NTCLD)
                 XU=TX(NTCLD)-HS
                 XD=TX(NTCLD)+HS
                 ZL=TZ(NTCLD)-HS
                 ZR=TZ(NTCLD)+HS
          C      DETERMINE GRID SQUARES FOR PLACEMENT OF MATERIAL ON B
          C      ASSUME EQUAL DISTRIBUTION AMONG GRID POINTS
                 NL=ZL/DX+0.5
                 MU=XU/DX+0.5
                 NR=ZR/DX+0.5
                 MD=XD/DX+0.5
                 IF(NL .LT. 1) NL=1
                 IF(NR .GT. NMAX) NR=NMAX
```

MODEL LISTING (73 of 85)

```
      IF(MU .LT. 1) MU=1
      IF(MD .GT. MMAX) MD=MMAX
      NSQRS=(MD-MU+1)*(NR-NL+1)
      IF(NSQRS .GE. 4) GO TO 830
      NSQRS=1
      MD=MX
      MU=MX
      NR=NZ
      NL=NZ
  830 CONTINUE
      IF(XS .GE. DIST) GO TO 430
      IF(XS .GE. 0.) GO TO 412
      IF(ABS(XS) .GT. TTHK(NTCLD)) GO TO 420
      IF(TTOP(NTCLD) .GT. D2) GO TO 420
      FALOUT =ABS(XS)/TTHK(NTCLD)*TMASS(NTCLD)
      DO 800 MM=MU,MD
      DO 800 NN=NL,NR
  800 ACCUM(NN,MM)=ACCUM(NN,MM)+FALOUT/FLOAT(NSQRS)
      TMASS(NTCLD)=TMASS(NTCLD)-FALOUT
      TTHK(NTCLD)=TTHK(NTCLD)-ABS(XS)
      GO TO 411
  412 IF(TTHK(NTCLD) .LT. (DIST-XS)) GO TO 420
      FALOUT =(DIST-XS)/TTHK(NTCLD)*TMASS(NTCLD)
      DO 810 MM=MU,MD
      DO 810 NN=NL,NR
 810  ACCUM(NN,MM)=ACCUM(NN,MM)+FALOUT/FLOAT(NSQRS)
      TMASS(NTCLD)=TMASS(NTCLD)-FALOUT
      TTHK(NTCLD)=TTHK(NTCLD)-(DIST-XS)
      TTOP(NTCLD)=TTOP(NTCLD)+DIST-DTOP
      GO TO 440
  420 DO 820 MM=MU,MD
      DO 820 NN=NL,NR
  820 ACCUM(NN,MM)=ACCUM(NN,MM)+TMASS(NTCLD)/FLOAT(NSQRS)
C     ERASE CLOUD
      TMASS(NTCLD)=0.
      TX(NTCLD)=0.
      TZ(NTCLD)=0.
      TSIDE(NTCLD)=0.
      TTHK(NTCLD)=0.
      TTOP(NTCLD)=0.
      VOLSC(NTCLD)=0.0
      TEMAS(NTCLD)=0.0
      NTCLD=NTCLD-1
      GO TO 440
  430 TTOP(NTCLD)=TTOP(NTCLD)+DIST-DTOP
  440 CONTINUE
      IF((TTOP(NTCLD)+TTHK(NTCLD)).GT. D2)TTOP(NTCLD)=D2-TTHK(NTCLD)
C
      VOLSC(NTCLD)=TTHK(NTCLD)*TSIDE(NTCLD)**2
      IF(K .NE. NSP1) GO TO 700
      TEMAS(NTCLD)=TEMAS(NTCLD)+(VOLSC(NTCLD)-VOL)*CBACK(NSP1)
      TMASS(NTCLD)=TMASS(NTCLD)+(VOLSC(NTCLD)-VOL)*CBACK(NSP1)
      IF(TMASS(NTCLD) .LT. 1.0E-10) GO TO 700
      DR=(TMASS(NTCLD)/VOLSC(NTCLD))/CINIT
      IF(DR .GT. DC(ITD)) GO TO 700
      TD(ITD)=DTL
      ITD=ITD+1
  700 IF(NEWT .EQ. ISTEP) RETURN
      GO TO 100
      END
      SUBROUTINE ACAD(K,C,THICK,TOP,ACCUM,DEPTH,U,W,TSIDE,TTHK,TTOP
     1, TMASS,TX,TZ,NMAX,MMAX,ETS)
C     DUMP MODEL
C     ROUTINE TO ANALYTICALLY CONVECT AND DIFFUSE DREDGED MATERIAL
C     CLOUDS THAT ARE TOO SMALL TO BE DEFINED BY THE NORMAL GRID.
C     IF A CLOUD GROWS BIGGER THAN STEPSIZE DX, THEN IT IS INSERTED INTO
C     NORMAL GRID.
C
      DIMENSION DEPTH(31,31)
      DIMENSION THICK(31,31),TOP(31,31),ACCUM(31,31)
     1,TSIDE(100),TTHK(100),TTOP(100),TMASS(100),TX(100),TZ(100)
     2 ,C(31,31)
      COMMON/NC/ NTCLD
      COMMON/DIMEN/ NS,NSP1,NVL,NSC
      DIMENSION U(31,31,2),W(31,31,2)
      COMMON/BAY/ DX,DTL,XRARGE,ZRARGE,DXH,DXR,AREA
      COMMON/PIECES/ PARAM(13),ROAS(13),CS(13),VFALL(13),VOIDS(13),BVOID
     1,ICOHES(12),VFALLC(13),VFALSC(20,13),VFALLD(31,31,13)
      COMMON/LTCOF/ ALAMDA,DIF,AKY0
      COMMON/LOST/ GONE
      COMMON/GPI/ G,PI,RB
      COMMON/ENTRAN/ TEMAS(100),VOLSC(100)
      COMMON/FLEE/ ITD,TD(6),DC(6),CINIT,CBACK(13),CTRACE(600)
      COMMON/CLOUD/T(600),CX(600),CY(600),CZ(600),CU(600),CV(600)
     1, CW(600),DENDIF(600),RC(600),AA(600),FC(600),VF
C
C     CHECK CLOUD FOR INJECTION TO LONG TERM GRID
      N=1
      NTEMP=NTCLD
   60 CONTINUE
C     CHECK CLOUD SIZE...IF LARGE ENOUGH, INJECT INTO NORMAL GRID
      IERASE=0
      IF(TMASS(N) .EQ. 0.) GO TO 70
C     CHECK FOR SMALL CLOUDS ON OR OUTSIDE OF GRID BOUNDARIES
      MXC=TX(N)*DXR+.0001
      NZC=TZ(N)*DXR+.0001
      IF(MXC .GT. MMAX .OR. MXC .LT. 1 .OR. NZC .GT. NMAX .OR. NZC .LT.
     1   1) GO TO 250
      IF(TSIDE(N) .GE. 2.*DX) GO TO 200
      IF(TSIDE(N) .LT. DX) GO TO 100
C     ....HERE TO INJECT A SMALL CLOUD INTO THE NORMAL GRID
C     ASSIGN CLOUD MATERIAL TO FOUR NEAREST GRID POINTS
      MX=TX(N)/DX+.0001
```

MODEL LISTING (76 of 85)

```
      NZ=TZ(N)/DX+.0001
      PROPX=(TX(N)-FLOAT(MX)*DX)/DX
      IF(PROPX .LT. .0001) PROPX=0.
      VOL=AREA*TTHK(N)
      XMASS2=PROPX*TMASS(N)
      XVOL2=PROPX*VOLSC(N)
      XMASS1=TMASS(N)-XMASS2
      XVOL1=VOLSC(N)-XVOL2
      PROPZ=(TZ(N)-FLOAT(NZ)*DX)/DX
      IF(PROPZ .LT. .0001) PROPZ=0.
      TMASS2=PROPZ*XMASS1
      VOL2=PROPZ*XVOL1
      TMASS1=XMASS1-TMASS2
      VOL1=XVOL1-VOL2
      TMASS4=PROPZ*XMASS2
      VOL4=PROPZ*XVOL2
      TMASS3=XMASS2-TMASS4
      VOL3=XVOL2-VOL4
C
      IF(TMASS1 .EQ. 0.) GO TO 61
      IF(C(NZ,MX) .NE. CBACK(K)) GO TO 610
C     HERE TO ADD MATL TO EMPTY GRID
      C(NZ,MX)=TMASS1/VOL1
      THICK(NZ,MX)=TTHK(N)*VOL1/VOL
      TOP(NZ   ,MX   )=TTOP(N)
      IF((TOP(NZ,MX)+THICK(NZ,MX)).GT. DEPTH(NZ,MX))TOP(NZ,MX)=
     1DEPTH(NZ,MX)-THICK(NZ,MX)
      GO TO 61
  610 CONTINUE
C     HERE ADD MATL TO NON-EMPTY GRID
      OM=C(NZ,MX)*THICK(NZ,MX)*AREA
      B1=TOP(NZ,MX)+THICK(NZ,MX)
      B2=TTOP(N)+TTHK(N)*VOL1/VOL
      BOT=AMAX1(B1,B2)
      IF(BOT .GT. DEPTH(NZ,MX))BOT=DEPTH(NZ,MX)
      TOP(NZ,MX)=AMIN1(TOP(NZ,MX),TTOP(N))
      OTHK=THICK(NZ,MX)
      THICK(NZ,MX)=BOT-TOP(NZ,MX)
      THDIF=THICK(NZ,MX)-OTHK-TTHK(N)*VOL1/VOL
      IF(THDIF .GE. 0.0)C(NZ,MX)=(OM+TMASS1+CBACK(K)*THDIF*AREA)/
     1(THICK(NZ,MX)*AREA)
      IF(THDIF .GE. 0.0) GO TO 61
C     MAKE SURE THICKNESS RESULTS IN VOLUME CONSERVATION
```

```
      GVOL=OTHK*AREA
      THICK(NZ,MX)=(GVOL+VOL1)/AREA
      IF((TOP(NZ,MX)+THICK(NZ,MX)) .GT. DEPTH(NZ,MX))TOP(NZ,MX)=
     1DEPTH(NZ,MX)-THICK(NZ,MX)
      C(NZ,MX)=(OM+TMASS1)/(THICK(NZ,MX)*AREA)
   61 IF(TMASS2 .EQ. 0.) GO TO 62
      IF(C(NZ+1,MX) .NE. CBACK(K)) GO TO 620
C     HERE TO ADD MATL TO EMPTY GRID
      C(NZ+1,MX)=TMASS2/VOL2
      THICK(NZ+1,MX)=TTHK(N)*VOL2/VOL
      TOP(NZ+1,MX   )=TTOP(N)
      IF((TOP(NZ+1,MX)+THICK(NZ+1,MX)) .GT. DEPTH(NZ+1,MX))
     1TOP(NZ+1,MX)=DEPTH(NZ+1,MX)-THICK(NZ+1,MX)
      GO TO 62
  620 CONTINUE
C     HERE TO ADD MATL TO NON-EMPTY GRID
      OM=C(NZ+1,MX)*THICK(NZ+1,MX)*AREA
      B1=TOP(NZ+1,MX)+THICK(NZ+1,MX)
      B2=TTOP(N)+TTHK(N)*VOL2/VOL
      BOT=AMAX1(B1,B2)
      IF(BOT .GT. DEPTH(NZ+1,MX))BOT=DEPTH(NZ+1,MX)
      TOP(NZ+1,MX)=AMIN1(TOP(NZ+1,MX),TTOP(N))
      OTHK=THICK(NZ+1,MX)
      THICK(NZ+1,MX)=BOT-TOP(NZ+1,MX)
      THDIF=THICK(NZ+1,MX)-OTHK-TTHK(N)*VOL2/VOL
      IF(THDIF .GE. 0.0)C(NZ+1,MX)=(OM+TMASS2+CBACK(K)*THDIF*AREA)/
     1(THICK(NZ+1,MX)*AREA)
      IF(THDIF .GE. 0.0) GO TO 62
C     MAKE SURF THICKNESS RESULTS IN VOLUME CONSERVATION
      GVOL=OTHK*AREA
      THICK(NZ+1,MX)=(GVOL+VOL2)/AREA
      IF((TOP(NZ+1,MX)+THICK(NZ+1,MX)) .GT. DEPTH(NZ+1,MX))TOP(NZ+1,MX)
     1=DEPTH(NZ+1,MX)-THICK(NZ+1,MX)
      C(NZ+1,MX)=(OM+TMASS2)/(THICK(NZ+1,MX)*AREA)
   62 IF(TMASS3 .EQ. 0.) GO TO 63
      IF(C(NZ,MX+1) .NE. CBACK(K)) GO TO 630
C     HERE ADD MATL TO EMPTY GRID
      C(NZ,MX+1)=TMASS3/VOL3
      THICK(NZ,MX+1)= TTHK(N)*VOL3/VOL
      TOP(NZ   ,MX+1)=TTOP(N)
      IF((TOP(NZ,MX+1)+THICK(NZ,MX+1)).GT. DEPTH(NZ,MX+1))
     1TOP(NZ,MX+1)=DEPTH(NZ,MX+1)-THICK(NZ,MX+1)
      GO TO 63
  630 CONTINUE
C     HERE ADD MATL TO NON-EMPTY GRID
      OM=C(NZ,MX+1)*THICK(NZ,MX+1)*AREA
      B1=TOP(NZ,MX+1)+THICK(NZ,MX+1)
      B2=TTOP(N)+TTHK(N)*VOL3/VOL
      BOT=AMAX1(B1,B2)
      IF(BOT .GT. DEPTH(NZ,MX+1)) BOT=DEPTH(NZ,MX+1)
      TOP(NZ,MX+1)=AMIN1(TOP(NZ,MX+1),TTOP(N))
      OTHK=THICK(NZ,MX+1)
      THICK(NZ,MX+1)=BOT-TOP(NZ,MX+1)
      THDIF=THICK(NZ,MX+1)-OTHK-TTHK(N)*VOL3/VOL
      IF(THDIF .GE.  0.0)C(NZ,MX+1)=(OM+TMASS3+CBACK(K)*THDIF*AREA)/
     1(THICK(NZ,MX+1)*AREA)
      IF(THDIF .GE. 0.0) GO TO 63
C     MAKE SURE THICKNESS RESULTS IN VOLUME CONSERVATION
      GVOL=OTHK*AREA
      THICK(NZ,MX+1)=(GVOL+VOL3)/AREA
      IF((TOP(NZ,MX+1)+THICK(NZ,MX+1)) .GT. DEPTH(NZ,MX+1))TOP(NZ,MX+1)
     1=DEPTH(NZ,MX+1)-THICK(NZ,MX+1)
      C(NZ,MX+1)=(OM+TMASS3)/(THICK(NZ,MX+1)*AREA)
   63 IF(TMASS4 .EQ. 0.) GO TO 64
      IF(C(NZ+1,MX+1) .NE. CBACK(K)) GO TO 640
C     HERE ADD MATL TO EMPTY GRID
      C(NZ+1,MX+1)=TMASS4/VOL4
      THICK(NZ+1,MX+1)=TTHK(N)*VOL4/VOL
      TOP(NZ+1,MX+1)=TTOP(N)
      IF((TOP(NZ+1,MX+1)+THICK(NZ+1,MX+1)) .GT. DEPTH(NZ+1,MX+1))
     1TOP(NZ+1,MX+1)=DEPTH(NZ+1,MX+1)-THICK(NZ+1,MX+1)
      GO TO 64
  640 CONTINUE
C     HERE ADD MATL TO NON-EMPTY GRID
      OM=C(NZ+1,MX+1)*THICK(NZ+1,MX+1)*AREA
      B1=TOP(NZ+1,MX+1)+THICK(NZ+1,MX+1)
      B2=TTOP(N)+TTHK(N)*VOL4/VOL
      BOT=AMAX1(B1,B2)
      IF(BOT .GT. DEPTH(NZ+1,MX+1))BOT=DEPTH(NZ+1,MX+1)
      TOP(NZ+1,MX+1)=AMIN1(TOP(NZ+1,MX+1),TTOP(N))
      OTHK=THICK(NZ+1,MX+1)
      THICK(NZ+1,MX+1)=BOT-TOP(NZ+1,MX+1)
      THDIF=THICK(NZ+1,MX+1)-OTHK-TTHK(N)*VOL4/VOL
      IF(THDIF .GE. 0.0)C(NZ+1,MX+1)=(OM+TMASS4+CBACK(K)*THDIF*AREA)/
     1(THICK(NZ+1,MX+1)*AREA)
      IF(THDIF .GE. 0.0) GO TO 64
```

```
C     MAKE SURE THICKNESS RESULTS IN VOLUME CONSERVATION
      GVOL=OTHK*AREA
      THICK(NZ+1,MX+1)=(GVOL+VOL4)/AREA
      IF((TOP(NZ+1,MX+1)+THICK(NZ+1,MX+1)) .GT. DEPTH(NZ+1,MX+1))TOP(NZ+
     11,MX+1)=DEPTH(NZ+1,MX+1)-THICK(NZ+1,MX+1)
      C(NZ+1,MX+1)=(OM+TMASS4)/(THICK(NZ+1,MX+1)*AREA)
   64 CONTINUE
      GO TO 70
C     ...HERE TO INJECT CLOUDS WITH SIDE GREATER THAN 2*DX
  200 CONTINUE
C     DETERMINE COORDINATES OF CORNERS
      HS=.5*TSIDE(N)
      XU=TX(N)-HS
      XD=TX(N)+HS
      ZL=TZ(N)-HS
      ZR=TZ(N)+HS
C     DETERMINE GRID SQUARES TO GET CLOUD MASS
      NL=ZL/DX+0.5
      MU=XU/DX+0.5
      NR=ZR/DX+0.5
      MD=XD/DX+0.5
      IF(NL .LT. 1) NL=1
      IF(NR .GT. NMAX)NR=NMAX
      IF(MU .LT. 1) MU=1
      IF(MD .GT. MMAX) MD=MMAX
      NSQRS=(MD-MU+1)*(NR-NL+1)
      SIDE2=TSIDE(N)**2
      DO 220 MM=MU,MD
      DO 220 NN=NL,NR
      X1=FLOAT(MM)*DX-DXH
      IF(MM .EQ. MU) X1=XU
      X2=FLOAT(MM)*DX+DXH
      IF(MM .EQ. MD) X2=XD
      Z1=FLOAT(NN)*DX-DXH
      IF(NN .EQ. NL) Z1=ZL
      Z2=FLOAT(NN)*DX+DXH
      IF(NN .EQ. NR)Z2=ZR
      IF(C(NN,MM) .NE. CRACK(K)) GO TO 210
C     ADD MATL TO EMPTY GRID
      TOP(NN,MM)=TTOP(N)
      THICK(NN,MM)=TTHK(N)*SIDE2/(FLOAT(NSQRS)*AREA)
      IF((TOP(NN,MM)+THICK(NN,MM)) .GT. DEPTH(NN,MM))TOP(NN,MM)=
     1DEPTH(NN,MM)-THICK(NN,MM)
```

```
      C(NN,MM)=(TMASS(N)/FLOAT(NSQRS))/(THICK(NN,MM)*AREA)
      GO TO 215
  210 CONTINUE
C     HERE ADD MATL TO NON-EMPTY GRID
      OM=C(NN,MM)*THICK(NN,MM)*AREA
      B1=TOP(NN,MM)+THICK(NN,MM)
      B2=TTOP(N)+TTHK(N)*SIDE2/(FLOAT(NSQRS)*AREA)
      BOT=AMAX1(B1,B2)
      IF(BOT .GT. DEPTH(NN,MM))BOT=DEPTH(NN,MM)
      TOP(NN,MM)=AMIN1(TOP(NN,MM),TTOP(N))
      OTHK=THICK(NN,MM)
      THICK(NN,MM)=BOT-TOP(NN,MM)
      THDIF=THICK(NN,MM)-OTHK-TTHK(N)*SIDE2/(FLOAT(NSQRS)*AREA)
      IF(THDIF .GE. 0.0)C(NN,MM)=(OM+TMASS(N)/FLOAT(NSQRS)+CBACK(K)*
     1THDIF*AREA)/(THICK(NN,MM)*AREA)
      IF(THDIF .GE. 0.0) GO TO 215
C     MAKE SURE THICKNESS RESULTS IN VOLUME CONSERVATION
      GVOL=OTHK*AREA
      THICK(NN,MM)=(GVOL+VOLSC(N)/FLOAT(NSQRS))/AREA
      C(NN,MM)=(OM+TMASS(N)/FLOAT(NSQRS))/(THICK(NN,MM)*AREA)
  215 CONTINUE
  220 CONTINUE
C     HERE COLLECT MASS SPILLED OUT OF BOUNDARY FROM LARGE CLOUD
      GO TO 70
  250 CONTINUE
C     HERE COLLECT MASS PASSING THROUGH GRID BOUNDARY
      GONE=GONE+TMASS(N)-TEMAS(N)
C
C     ERASE TRANSITION CLOUD AND MOVE CLOUDS BEHIND IT UP ONE SLOT
   70 NTEMP=NTEMP-1
      IERASE=1
      DO 80 I=N,NTEMP
      TSIDE(I)=TSIDE(I+1)
      TTHK(I)=TTHK(I+1)
      TTOP(I)=TTOP(I+1)
      TMASS(I)=TMASS(I+1)
      TEMAS(I)=TEMAS(I+1)
      VOLSC(I)=VOLSC(I+1)
      TX(I)=TX(I+1)
      TZ(I)=TZ(I+1)
   80 CONTINUE
      TSIDE(NTEMP+1)=0.
      TTHK(NTEMP+1)=0.
      TTOP(NTEMP+1)=0.
      TMASS(NTEMP+1)=0.
      TEMAS(NTEMP+1)=0.0
      VOLSC(NTEMP+1)=0.0
      TX(NTEMP+1)=0.
      TZ(NTEMP+1)=0.
  100 CONTINUE
      IF(IERASE .EQ. 0) N=N+1
      IF(N .LE. NTEMP) GO TO 60
      NTCLD=NTEMP
      IF(NTCLD .EQ. 0) RETURN
C
C     LOOP ONCE FOR EACH CLOUD
      IF(K .EQ. NSP1)VOL=TTHK(NTCLD)*TSIDE(NTCLD)**2
      DO  53 N=1,NTCLD
C     CONVECT....
C     DETERMINE HORIZONTAL VELOCITIES
      YY=TTOP(N)+.5*TTHK(N)
      CALL VEL(TX(N),YY,TZ(N),UA,WA,U,W,DEPTH,NMAX,MMAX)
      CALL DINT(TX(N),TZ(N),D1,DEPTH,NMAX,MMAX)
      TX(N)=TX(N)+UA*DTL
      TZ(N)=TZ(N)+WA*DTL
C     CHECK FOR SMALL CLOUD PASSING OUT OF GRID BOUNDARY
      NCHK=TZ(N)*DXR
      MCHK=TX(N)*DXR
      IF(NCHK .LT. 1 .OR. NCHK .GT. NMAX .OR. MCHK .LT. 1 .OR. MCHK .GT.
     1  MMAX) WRITE(6,405)
  405 FORMAT(/5X,101H---WARNING---A SMALL CLOUD HAS PASSED OUT OF GRID B
     1OUNDARY IN SUBROUTINE BOOKS...ERRORS WILL OCCUR---  )
      CALL DINT(TX(N),TZ(N),D2,DEPTH,NMAX,MMAX)
C     DTOP ESTIMATES VARIATION OF CLOUD DEPTH DUE TO CONVECTION OVER
C     VARIABLE DEPTHS
      DTOP=(D1-D2)*TTOP(N)/D1
C     ...DIFUSE HORIZONTALLY...
      VFALSC(N,K)=VFALL(K)
      IF(ICOHES(K) .EQ. 0) GO TO 407
      SCONC=(TMASS(N)/(TSIDE(N)**2*TTHK(N)))*2600000.
      IF(SCONC .LE. 25.) VFALSC(N,K)=0.0017
      IF(SCONC .GT. 25. .AND. SCONC .LE. 300.) VFALSC(N,K)=
     1(0.00713*SCONC**1.33333)/304.8
      IF(SCONC .GT. 300.)VFALSC(N,K)=0.047
  407 CONTINUE
      TSIDE(N)=TSIDE(N)*(1.+(1.333333*ALAMDA/TSIDE(N)**.666666)*DTL)
```

```
          1 **1.5
C          SETTLE....
           IF(K .EQ. NSP1) GO TO 50
           DIST=VFALSC(N,K)*DTL
           MX=TX(N)*DXR + .5
           NZ=TZ(N)*DXR + .5
           HS=0.5*TSIDE(N)
           XU=TX(N)-HS
           XD=TX(N)+HS
           ZL=TZ(N)-HS
           ZR=TZ(N)+HS
C          DETERMINE GRID SQUARES FOR PLACEMENT OF MATERIAL ON BOTTOM
C          ASSUME EQUAL DISTRIBUTION AMONG GRID POINTS
           NL=ZL/DX+0.5
           MU=XU/DX+0.5
           NR=ZR/DX+0.5
           MD=XD/DX+0.5
           IF(NL .LT. 1)NL=1
           IF(NR.GT. NMAX) NR=NMAX
           IF(MU .LT. 1) MU=1
           IF(MD .GT. MMAX) MD=MMAX
           NSQRS=(MD-MU+1)*(NR-NL+1)
           IF(NSQRS .GE. 4) GO TO 730
           NSQRS=1
           MD=MX
           MU=MX
           NR=NZ
           NL=NZ
       730 CONTINUE
       411 XS=DEPTH(NZ,MX)-TTOP(N)-TTHK(N)-DTOP
           IF(XS .GE. DIST) GO TO 40
           IF(XS .GE. 0.) GO TO 412
           IF(ABS(XS) .GT. TTHK(N)) GO TO 30
           FALOUT=ABS(XS)/TTHK(N)*TMASS(N)
           DO 740 MM=MU,MD
           DO 740 NN=NL,NR
       740 ACCUM(NN,MM)=ACCUM(NN,MM)+FALOUT/FLOAT(NSQRS)
           TMASS(N)=TMASS(N)-FALOUT
           TTHK(N)=TTHK(N)-ABS(XS)
           GO TO 411
       412 IF(TTHK(N) .LT. (DIST-XS)) GO TO 30
           FALOUT =(DIST-XS)/TTHK(N)*TMASS(N)
           DO 710 MM=MU,MD
```

```
      DO 710 NN=NL,NR
  710 ACCUM(NN,MM)=ACCUM(NN,MM)+FALOUT/FLOAT(NSQRS)
      TMASS(N)=TMASS(N)-FALOUT
      TTHK(N)=TTHK(N) - (DIST-XS)
      TTOP(N) = TTOP(N) + DIST-DTOP
      GO TO 50
   30 DO 720 MM=MU,MD
      DO 720 NN=NL,NR
  720 ACCUM(NN,MM)=ACCUM(NN,MM)+TMASS(N)/FLOAT(NSQRS)
      TMASS(N)=0.
      GO TO 50
   40 TTOP(N)=TTOP(N) + DIST-DTOP
   50 CONTINUE
C     ...DIFUSE VERTICALLY...
      DO 53 IDTL=1,10
      OTOP=TTOP(N)
      MX=TX(N)*DXR+.5
      NZ=TZ(N)*DXR+.5
      CALL VDIFCO(NZ,MX,OTOP,DCO,U,W,DEPTH,NMAX,MMAX,NVL)
      DINK=2.0*SQRT(DCO*DTL/10.0)
      TTOP(N)=TTOP(N)-DINK
      IF(TTOP(N) .LT. 0.) TTOP(N)=0.
      OBOT=OTOP+TTHK(N)
      IF(OBOT .GT. DEPTH(NZ,MX)) OBOT=DEPTH(NZ,MX)
      CALL VDIFCO(NZ,MX,OBOT,DCO,U,W,DEPTH,NMAX,MMAX,NVL)
      DONK=2.0*SQRT(DCO*DTL/10.0)
      IF((OBOT+DONK) .GT. DEPTH(NZ,MX))DONK=DEPTH(NZ,MX)-OBOT
      TTHK(N)=TTHK(N)+DINK+DONK
      IF((TTOP(N)+TTHK(N)) .GT. DEPTH(NZ,MX))TTOP(N)=
     1DEPTH(NZ,MX)-TTHK(N)
      OLDVOL=VOLSC(N)
      VOLSC(N)=TTHK(N)*ISIDE(N)**2
      TEMAS(N)=TEMAS(N)+(VOLSC(N)-OLDVOL)*CBACK(K)
      TMASS(N)=TMASS(N)+(VOLSC(N)-OLDVOL)*CBACK(K)
   53 CONTINUE
      NTEMP=NTCLD
      L=1
  500 IF(TMASS(L) .NE. 0.) GO TO 570
      NTEMP=NTEMP-1
      DO 520 I=L,NTEMP
      TMASS(I)=TMASS(I+1)
      TEMAS(I)=TEMAS(I+1)
      VOLSC(I)=VOLSC(I+1)
```

```
SUBROUTINE  ACAD                              CDC 6400 FTN V3.0- BPA OPT=1  05/21/79  17.06.04.      PAGE     10
                TSIDE(I)=TSIDE(I+1)
                TTHK(I)=TTHK(I+1)
                TTOP(I)=TTOP(I+1)
                TX(I)=TX(I+1)
            520 TZ(I)=TZ(I+1)
            570 IF(L .GE. NTEMP) GO TO 580
                L=L+1
                GO TO 500
            580 NTCLD=NTEMP
                IF(K .NE. NSP1) RETURN
          C     CHECK FLUID DILUTION
                CMAX=0.
                NSAVE=1
                DO 700 N=1,NTCLD
                CT=TMASS(N)/VOLSC(N)
                CMAX=AMAX1(CMAX,CT)
                IF(ABS(CMAX-CT) .LT. .0001) NSAVE=N
            700 CONTINUE
                IF((CMAX-CRACK(NSP1)) .LT. 1.E-30) GO TO 460
                DR=CT/CINIT
                IF(DR .GT. DC(ITD)) GO TO 460
                TD(ITD)=ETS
                ITD=ITD+1
            460 CONTINUE
                RETURN
                END
```

MODEL LISTING (85 of 85)